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1935 • 1936

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Contents

Flat Rolling of Steel—Factors Influencing Its Production—by C. L. McGranahan, Supt. 76″ Hot Strip Mill, Inland Steel Company, Indiana Harbor, Ind. 1

Discussion—Flat Rolling of Steel—Factors Influencing Its Production—Discussion presented by F. E. Flynn, R. W. Graham, C. L. McGranahan, A. S. Hellstrom, R. J. Wean, J. H. Van Campen, H. D. Esterly and J. Farrington 8

Flat Rolled Steel Products—Processing for Automotive Industry—by R. J. Wean, President, Wean Engineering Co., Inc., Warren, Ohio 12

Discussion—Flat Rolled Steel Products—Processing for Automotive Industry—Discussion presented by C. L. McGranahan, R. J. Wean and F. E. Flynn 15

Individual Motor Drives—for Runout Tables and Coiler Rolls—by W. B. Snyder and L. E. Hildebrand, General Electric Company 16

Selection of Lubricants—for Cold Rolling of Strip Steel—by Dr. R. W. Moore, Metallurgist and Chemist and E. S. Reynolds, Ind. Lub. Engineer, Socony-Vacuum Oil Company 24

Roll Table Equipment—for Modern Wide Strip Mills—by G. A. Caldwell and S. F. Henderson, Westinghouse Electric & Mfg. Company 29

Discussion—Roll Table Equipment—for Modern Wide Strip Mills—Discussion presented by J. Farrington, B. A. Shrive, J. W. Bates, W. B. Snyder and A. M. MacCutcheon 39

Developments in Flat Steel Rolling—by Stephen Badlam, Consulting Engineer, Pittsburgh, Pa. 40

Iron and Steel Engineer Index for 1935 51

Brent Wiley elected Managing Director of the Association 57

Items of Interest 58

Convention and Iron and Steel Exposition ..... II and III

Index to Advertisers IV

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AST MARKETS FOR STEEL FORECAST

Air Conditioning, Housing Called New Fields

By GEORGE SNYDER
Business Editor

Two vital developments were seen in the steel industry as the ... of Iron and Steel ... today for ...

SDAY, SEPTEMBER 24, 1935

STEEL CHIEF HITS 'ALIENS' IN UNIONS

Convention Hears Federal 'Dictation' Attacked

Striking at "bureautratic dic... tion," and outside unions, Ar... H. Young, vice president of ... States Steel Corpora... defense of the com... steel industry ...

STRIP steel is ... instead of b... Pittsburgh is real... industry, accordin... superintendent o... District.

Mr. Flynn to... convention of the A... Iron & Steel Electri... William Pen...

Steel Convention ... Of Production;

Technical Problems, New Uses Included on Program of Sessions

Technical ...

ABOR BOARD'S FUTILITY' TOLD STEEL LEADERS

...curity Program ...ved by ...

STEEL INDUSTRY TO GET BILLION

PWA to Spend Huge Amount ... Here, Says Director of ...l Division

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NEW JOBS ...

ONVENTION EXPERTS HAL...

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Company Union Plan In Labor Relations Defended.

A. H. YOUNG SPEAKS

Engineers Select Detroit For Convention to Be Held in 1936.

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Points

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...spoke before the ... Iron & Steel ... con... Hot... ...cal ...ass'n ...ro... ...th... ...te...

...dollar estimate ...oley, is based ...de by the ... Forty ...uld go ... Ind.

...ollar estimate ing to C. L. McGranahan, ... tendent of the Inland Steel Co... ...pany's big mill at Indiana Harbo...

"The outlook, so far as labo... ...concerned, is not so pessimistic ... it seems," McGranahan told a gr... ...of technical and research men ... convention of the Associatio... ...Iron and Steel Electrical Engine... ...in the William Penn Hotel.

...and modern method of making ... ...and better steel with less tro... ...is a necessary forward step ... cannot be retarded, McGran... declared.

The "buyer's market" ... prevailed for ...

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...ENGINEERS SET STEEL PACE

(Continued from Page Twenty-one.)

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1936
EEL EXPOSITION
O BE BIGGEST EVER

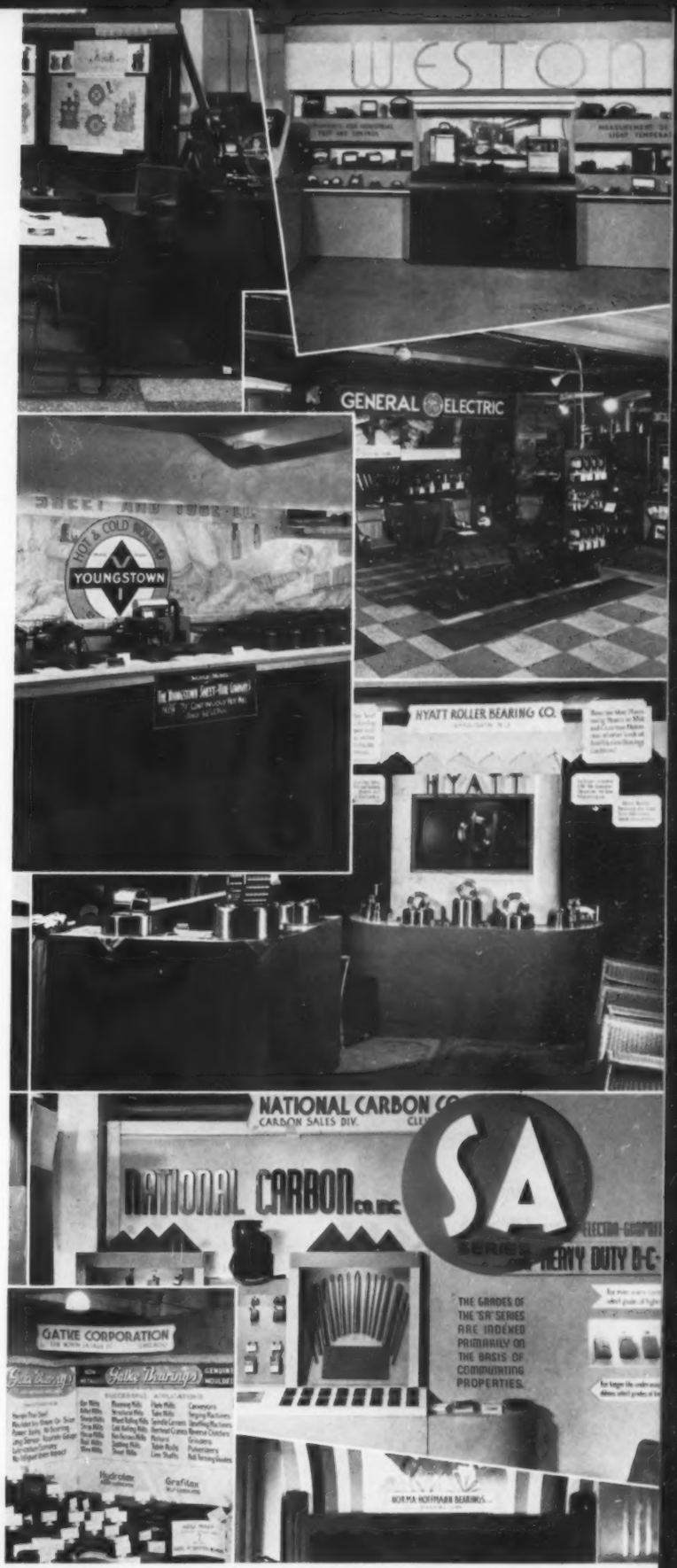
motive industry maintaining its position as steel's biggest customer, many producers are presented with an opportunity to further cultivate this great market.

The combination of both the machinery necessary to produce steel and the finished product being exhibited under the same roof will help the steel industry to present a united front to its largest consumer, as well as creating a better understanding of the mutual problems confronting each.

To be supplemented by a technical program designed to study the problems of producing steel, as well as those of its uses in the Detroit area, the coming Iron and Steel Exposition holds many benefits for the manufacturers in the metal working industry.

For details please write to the IRON AND STEEL EXPOSITION, 1010 Empire Building, Pittsburgh, Penna.

GAN SEPT. 22, 23, 24, 25



Top—A few of the many elaborate displays of steel mill equipment which were shown in the 1935 Exposition

Left—Presses for shaping body panels at the Fisher Body plant of General Motors Corporation. Steel producers plan exhibits for showing this great industry their latest steels.

INDEX TO ADVERTISERS

A	The Alliance Machine Co.	94
	Allis-Chalmers Manufacturing Company	98
	Aluminum Company of America	72
B	The Bantam Ball Bearing Co.	91
	The Bartlett Hayward Company	75
	Bussmann Mfg. Co.	60–61
C	The Cleveland Crane & Engineering Co.	82
	Cutler-Hammer, Inc.	Cover 2
E	The Electric Controller & Mfg. Co.	70
	The Electric Furnace Co.	88
F	Farrel-Birmingham Company, Inc.	93
G	General Electric Company	78–87–Cover 4
H	Helwig Co.	92
	The Hodson Corporation	67
	Hyatt Roller Bearing Company	81
I	I-T-E Circuit Breaker Company	Cover 3
J	Jefferson Electric Co.	80
L	Leeds & Northrup Company	85–99
	Lewis Foundry & Machine Company	68
	The Lincoln Electric Company	83
M	The Martindale Electric Co.	94
	McGraw Electric Company	60–61
	Mesta Machine Company	71
	The Morgan Engineering Co.	89
N	National Carbon Company, Inc.	96
	The New Departure Mfg. Company	65
	New York & New Jersey Lubricant Co.	92
	The Nichols-Lintern Co.	95
	Norma-Hoffmann Bearings Corporation	74
P	Pennsylvania Transformer Co.	96
	Poole Foundry & Machine Company	86
R	Reliance Electric & Engineering Co.	90
	Rockbestos Products Corporation	95
S	Schloemann Engineering Co.	66
	SKF Industries, Inc.	63
	B. F. Sturtevant Co.	79
	Surface Combustion Corporation	73
T	The Thompson Electric Co.	93
	The Timken Roller Bearing Company	100
	The Tool Steel Gear & Pinion Co.	84
W	The Wean Engineering Company, Inc.	69–Cover 1
	Westinghouse Electric & Mfg. Co.	76–77
	The Wellman Engineering Co.	97
	Lee Wilson Engineering Co.	69

FLAT ROLLING OF STEEL

FACTORS INFLUENCING ITS PRODUCTION

By C. L. McGRANAHAN
Supt. 76" Hot Strip Mill
INLAND STEEL COMPANY

Paper presented before the A. I. & S. E. E. Convention, Pittsburgh, Pennsylvania, September 24, 25, 26, 1935

▲ WHEN MR. STEPHEN BADLAM addressed the American Iron and Steel Institute in October, 1927, he opened his paper with the following remark: "The outstanding achievement of the present decade in the history of the rolling mill is the development in the art of rolling wide, thin sections, as exemplified by the wide strip mill and the continous sheet mill." The remarks are equally appropriate when applied to the present decade, and those of you who were fortunate enough to hear Mr. Badlam's paper when he addressed the spring meeting of this Association and his paper yesterday, in which he reviewed Sheet, Tin and Strip Mills, will, no doubt, agree with me that the year 1935 is witnessing the peak year for the construction of Hot Strip Mills.

This development has been made possible by the utilization of the 4-high rolling mill equipped with anti-friction bearings. The principle of the 4-High Mill was proposed 200 years ago by Christopher Polhem, the explanation of which was published in 1761, ten years after his death. In a discussion on the rolling of sheets, he gave the following description of the first 4-high mill of which we have record: "As such rolls commonly had a length of three-quarter, it follows that their diameter must be rather large; but, as thick rolls in comparison with slender ones have only a small effect in stretching, broad sheets cannot be rolled. If not, two slender wrot iron rolls are put together between the two thick cast iron rolls, which prevent the slender rolls from yielding. Such rolls I have put up at Stjernsund after having tried their effect by experiment on a small scale." Polhem was unable to continue his experiments due to financial difficulties and he concluded the description with the following words: "Yet, I willingly grant to others who perhaps will live during more happy times, what I have not got opportunity to use for myself." If the expenditures for new strip mills which are being made this year, or which have been authorized are an accurate indicator, then we are indeed living in a prosperous and happy time.

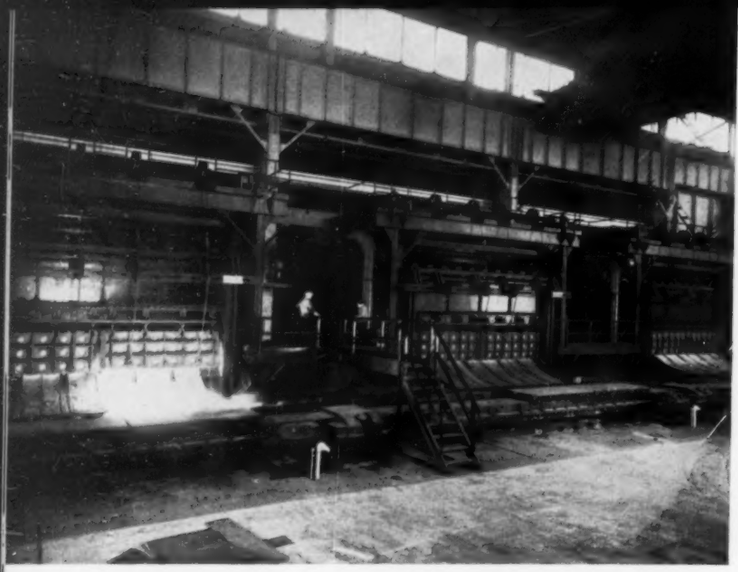
The 4-high mill, or backing-up roll principle, lay dormant until 1864, when it was revived by Mr. Bernard Lauth, who invented the 3-high plate mill and was followed by various patents which culminated in the installation of the Armor Plate Mill at Homestead in the early nineties. Three years previous to this time the continuous mill was invented by Charles White of

C. L. McGRANAHAN

Ponty Pridd, England. The utilization of the two principles in conjunction with each other was made possible to a great extent by the development of the variable speed direct current motor and large anti-friction bearings.

The early strip mills usually consisted of several stands of 3-high and 2-high Mills arranged in a straight line on a common bed plate, or consisted of a tandem roughing train and a strand finishing train. The arrangement of the train was modified from time to time as improvements in power and power transmission appeared, until finally the modern straight line, or tandem continuous mill was developed, as exemplified by the 20" 2-High continuous strip mill of the Otis Steel Company which was erected in 1923.

The early operator was confronted with such problems as disposal of the strip during the rolling operation, camber, surface requirements and uniformity of gage. The power reel replaced the fleet-footed boy, who was

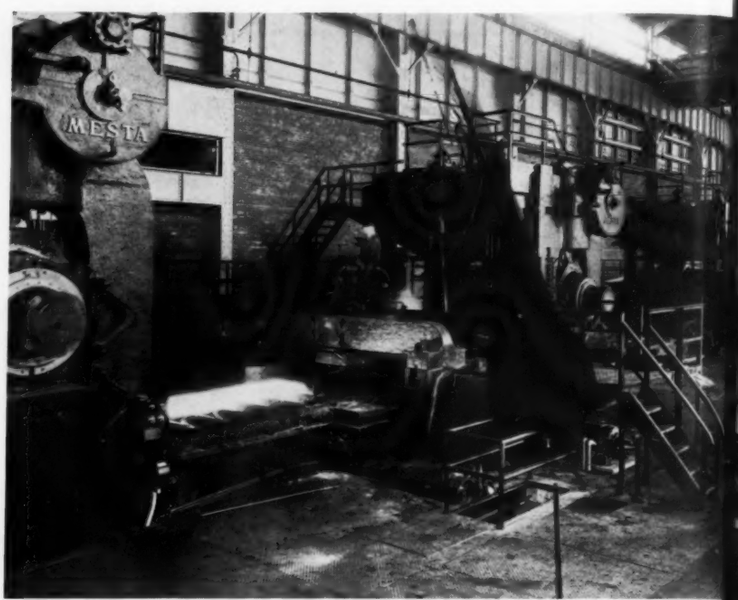


Discharge end of 3 slab reheating furnaces.

originally employed to carry the strip away; the steel scrapper and low pressure water assisted in the removal of the furnace scale on the narrower widths, and more rigid and higher speed mills assisted in overcoming the camber and uniformity of gage difficulties.

The modern 4-high continuous broad strip mill is usually equipped with every known device which will assist in overcoming the difficulties of the earlier mill; yet we still have with us the problem of the best method of the disposal of the strip after leaving the finishing stand, the question of camber on mill edge sheets and on long strips, variation in gage from edge to edge and end to end of individual sheets, uniform light tight oxide with drawing qualities, and last but not least, the difficult problem of flatness on wide sheets.

The cooperation between the machinery builder and mill operator has brought about the more or less standardization of broad strip mills, with the result that no single steel producer can claim any appreciable superiority of product due to mill equipment or arrangement of the stands, but can claim only that due to better grade of steel and to more efficient operation of the mill itself. This increase in competition has resulted in a material improvement in the quality of the product and it has been assisted by the Buyer's Market, which has prevailed for approximately six years. Surface requirements and flatness standards which would have commanded an extra in 1929 are now demanded on commercial deliveries and it is a difficult job frequently to tell a hot rolled pickled and oiled sheet from a heavy gaged cold rolled sheet. When all the mills now under construction are completed, there will, no doubt, be periods of 100 per cent operation for everyone, as well as slack periods. The operator is then faced with the problem of producing the best possible sheet in limited quantities with a reasonable cost upon a machine designed for mass production. Even with proper consideration to all the various factors entering Into the rolling of flat strip steel this is a difficult problem, although not necessarily an unsurmountable one. To reduce a broad strip to gage in a modern mill with a capable rolling crew is in itself not an extremely difficult task. To produce a strip of the proper surface requirement and of such shape that it can be flattened without destroying the surface, is easy or difficult, depending upon the amount of thought that has been given to the selection of the slab, the rate of heating, the percentage of draft in the various mills and the condition of the working and backing-up rolls when the section is being rolled. Many of these features are frequently beyond the control of the rolling crew and must be considered before making up the rolling schedule and before the rolling operations have begun. Unless proper consideration is given to the above factors and suitable facilities provided for the disposal of the strip after rolling, the finishing cost may be equal to or several times greater than the actual rolling cost.



Hydraulic squeezer on Inland's hot strip mill.

The observations in this paper will be based upon strip produced on a standardized broad strip mill consisting of a No. 1 Scale Breaker, a Spreading Stand, a Squeezer, Roughing Stands 2, 3 and 4, No. 2 Scale Breaker, and six Finishing Stands with suitable Run-out Table, Flying Shears and Coilers.

A discussion of the factors influencing uniformity of gage, surface, flatness and disposal of the strip naturally starts with the selection of the slab which may or may not effect all of them. This influence is more pronounced when rolling broad strip from a slab of such dimensions as to involve spreading for width and the major portion of our observations therefore will deal with sections somewhat wider than the maximum slab width, which varies from 36 to 44 in. in the majority of the strip mills, few of them being equipped with slabbing mills.

In most cases it is desirable to roll the maximum size of slab obtainable that can be heated in the slab heating furnaces, but subject to certain limiting factors imposed upon it by the width, capacity of the blooming mill or the slabbing mill, open hearth practice for good

rimming action or practical pouring heights on killed steel.

The length of the slab is also limited to the length that can be cross-rolled to width by the spreading stand and further by the economic feature that the ingot should be cut into a number of multiples of even weight or pattern slabs. Short slabs or blanks in the higher carbon ranges are not readily disposed of and an arbitrary method of ordering slabs of such weight as to not cut out economically should be looked upon with disfavor.

Mills which are equipped with a hot bed are subject to another factor which frequently works a serious hardship upon the heating furnace, namely that of heating a slab which will produce from 175 to 250 ft. of 16 gage narrow strip. A 60 in. long slab 3 in. thick produces the maximum length of 16 gage strip that can be handled upon a 250 ft. hot bed and a little study will convince any mill operator that this is a very undesirable length of slab to push through an 80 ft. long furnace. Any slab limited by the above-mentioned features will produce a sheet or strip of suitable cross-section, surface and flatness when rolled into the heavier gages by a capable rolling crew; but when rolled into wider gages, such as 14 gage 72 in.

General view of mill from roughing end.

wide, 16 gage 60 in. wide, or 18 gage 54 in. wide, it is then necessary to limit the length to the point where the back end will not drop below the minimum finishing temperature at which the strip can be rolled without biting in the mill. These slab lengths are usually short enough that the variation from front to back end will be well within the commercial range.

After a slab of the proper size has been decided upon, it is important to consider the amount of reconditioning or chipping necessary to produce a strip reasonably free from surface defects. It is necessary to bear in mind that even though the strip may not have any special surface requirements, a scabby slab may not be 100 per cent cleaned in the furnace and scale breaking stands, and that marked rolls result in curtailed operation due to increased roll changes or to increased rejections in the finishing department.

The visible surface defects are influenced by the size of the mould, depth of the ladle, size of the nozzle, condition of the mould walls, etc. These defects are partially removed by good soaking pit practice and careful handling in the blooming mill. Unless care is taken at this point, additional defects, such as burnt corners or torn surface or snakes are added.

It is readily apparent that drawing quality sheets should be made from reasonably clean slabs; that is, free from scabs, large snakes and burnt corners. On ordinary hot rolled sheets the question is decided by weighing the possible loss at the customer's plant against the chipping cost. Very little chipping should be necessary on slabs for plain hot rolled sheets with sheared edges, with normal conditions prevailing at the open hearth and the blooming mill. Where a good mill edge is demanded, the amount of steel set down for chipping may vary from 25 to 100 per cent, depending upon the plant open hearth and blooming mill practices.

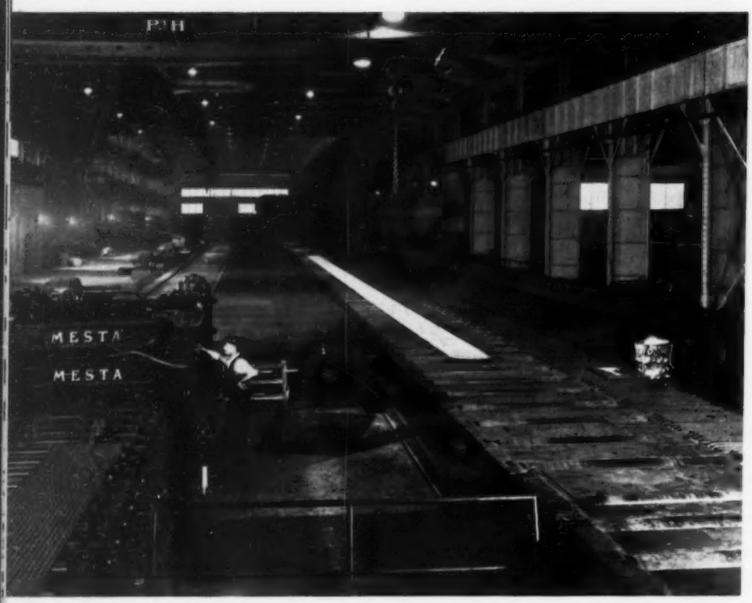
Defects on finished sheets sufficiently visible to cause rejection and which are made from slabs which have not been reconditioned, or only partially so, usually are in direct proportion to the thickness of the finished product. For this reason slabs for rolling into steel of flanging quality or pipe skelp, where the individual piece may weigh from one to several tons, should be carefully scrutinized before charging. This is especially true when the material is subject to outside inspection, as a pit .003 to .004 below commercial tolerance is sufficient to cause rejection of the finished plate.

We do not recommend the charging of hot slabs into the slab heating furnace where it is possible to avoid doing so, as our observations have indicated that a slab which has been charged cold into the heating furnace can be more readily descaled than one which has been charged hot. This is an extremely important feature when spreading slabs to width, as it is impos-

General view of mill from finishing end.

sible to control a partially descaled slab in the spreading stand when utilizing heavy drafts.

Heating furnaces are usually designed for the fundamental purpose of bringing a slab up to a good rolling temperature and at the same time producing a scale which may be readily removed by the scale removal facilities. Fortunately for the open hearth and the blooming mill departments a certain amount of cleansing or purification of the surface of the steel is incidental to this operation. The amount, however, cannot always



General view of run-out tables and cooling bed.

be definitely determined and this equipment should not be looked upon as a curative for faulty practices elsewhere. Heating a slab to a sufficiently high temperature to raise a good thick furnace scale, then soaking out the skid marks, practically eliminates the heating furnaces from being a factor in surface requirements, flatness and camber. The impracticability of "Washing Slabs" in broad strip mill operation is conclusively demonstrated after a few pile-ups upon the hot hearth, or after an effort is made to spread a slab to width, utilizing 45 per cent draft, which is quite common practice. When a slab has been properly heated, that is, heated sufficiently to raise a good thick scale, and soaked long enough to erase the skid marks and is discharged from the heating furnace, the impact is usually enough to loosen the scale sufficiently that it can be removed by means of a rake. Overheated or underheated slabs carry a tight scale and require considerable pressure at the scale breaking stand rolls to loosen the scale sufficiently so that it can be removed by the hydraulic spray system.

The majority of the broad strip mills are equipped with 2-high scale breaking stands assisted by a hydraulic spray system of suitable capacity with pressures ranging from 500 to 1200 lb. and do an excellent job when the mill is operating three consecutive turns, or with short idle period between turns. The operation is not so simple when the schedule calls for an idle eight-hour turn. It is the writer's opinion that a horizontal edger taking about a 1 in. draft is a more satisfactory piece of equipment for descaling slabs up to 44 in. in width when such operations are contemplated. This opinion is apparently not shared in by the leading mill builders. Fluted scale breaking rolls are not necessary when rolling slabs which have been charged cold, but give some benefit when rolling slabs which have been charged hot, if sufficient draft is used. This feature should be considered when the mill is being designed and sufficient power provided for reduction purposes, as well as for the plain scale removal. The scale breaking unit requires careful handling on cross-rolled strip, as its influence is felt on practically all of the troublesome problems of rolling broad strip (surface, camber, etc.).

The design of the nozzles, nozzle spacing and distance from slab and position with respect to the scale breaking stands has been more or less standardized and the equipment offered by the leading manufacturers of these articles is quite suitable for the purpose.

The operation of the roughing train materially affects gage variation, camber and flatness of the finished strip. It is not a difficult task to ruin a properly heated and descaled slab in a roughing train by resorting to excessive drafts and by too infrequent changing of the rolls in the various stands. It is common practice in many of the wider mills to use steel rolls in Stands No. 1 and 2, and sometimes Fluted Moly Chill Rolls in one or both of them. Stands No. 3 and 4 produce very satisfactory results with new Moly Chill Rolls, special hardened alloy rolls or rolls which have served their useful life in the finishing train. Very high tonnages can be rolled upon Stand No. 1 without materially affecting the surface and flatness of the strip. It is doubtful economy, however, to operate this stand or any of the roughing stands with fire-cracked rolls, even though the scale sprays apparently remove all of the resulting slivers before the strip enters the finishing stands.

The squeezer is an almost indispensible machine when spreading for width and it is also a very powerful machine. The operation is quite simple and is easily overdone, in which case, upset edges are produced with resulting long ears or fish tails and marked rolls in the finishing train.

The working rolls of Stands No. 2 and No. 3 have a marked influence upon the shape of the ends produced in the finishing train and the backing-up rolls have some effect, but not so pronounced. The surface and shape of the working rolls in No. 4 stand affect both surface and flatness of the finished strip and must be changed systematically.

When proper care is used in handling the various units in the roughing train, a flat bar of uniform cross-section with a square leading edge and of such gage and such temperature as to be readily descaled in No. 2 scale breaker is delivered to the finishing train. A careful study of the various operations of the equipment which has just been outlined will readily disclose the far reaching effect of poor manipulation of the spreading stand, the squeezer and the edgers in pro-

ducing cobbles either in this train or in the finishing train, in producing narrow sections due to stretching the bar between the vertical rolls and the working rolls, in necessitating roll changes in the finishing train due to their being marked by long ears or fish tails, and the variation in gage and flatness of the finished strip due to a non-uniform section being produced by the roughing train.

The No. 2 scale breaker is invariably equipped with smooth alloy steel rolls and functions primarily as a set of pinch rolls to maintain constant speed through the scale removal sprays.

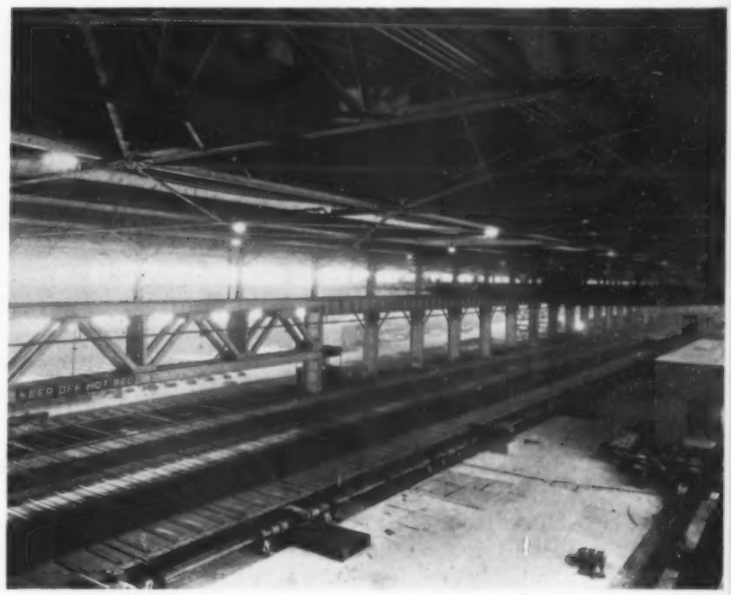
The first three finishing stands are usually equipped with Moly Chilled Rolls about 68 Scleroscope hardness and the last three stands use Nickel or Chrome Chilled Rolls ranging from 75 Scleroscope hardness in No. 8 Stand to 85 Scleroscope hardness in No. 10 Stand. When so equipped, the train will frequently produce from 2,000 to 2,500 tons of high grade wide sheets 13 gage and heavier by changing 5, 6 and 7 stands twice during this period. It is essential to have an adequate supply of clean cooling water during this performance.

The influence of the shape of the backing-up rolls in the finishing train is very noticeable when rolling sections such as, 13 gage 66 in. wide, 16 gage 62 in. wide, 18 gage 54 in. wide, etc. In fact it is so pronounced that it is frequently impossible to get the section through the mill, let alone produce a section which may be easily flattened. This condition makes itself manifest by causing a wavy edge delivery of the strip from the stand itself, or by biting up of the strip in the next stand. Within certain limits it can be corrected by a reduction in draft on the stand. When Stands No. 9 and 10 are involved, it is poor economy to continue to roll when the product unquestionably will give trouble if it is to be cold reduced to a lighter gage, or in flattening if it is to be shipped as a hot rolled product.

The shape of the working rolls, of course, has a very pronounced effect upon the shape of the strip delivered from the finishing stand. Due to there being changes so frequently they are less liable to give trouble on wide light sections than worn-out backing-up rolls. It is an easy matter to detect bad surface being produced by the working rolls and it is such a simple operation to change them when properly equipped to do so, that there is little reason for rolling steel when they are not in good condition.

The question most frequently asked by visitors is "What draft do you use in the various stands?" This may be answered just as briefly by stating that it varies from 60 per cent in No. 5 Stand to 10 per cent in No. 10 Stand, varies with every gage produced and varies with the production with any single gage, depending upon the tonnage rolled on the mill previous to the section in question and the amount of tonnage of that section. It also varies according to the finishing temperature being maintained and the ability of the various stands to carry the proper load as influenced by the condition of the backing-up rolls. The drafting of the mill varies within wide limits and the important feature to watch is that the section produced from the finishing stand is such that it lends itself readily to the flattening operation, namely a strip with a slight center buckle.

The camber and gage of the strip are influenced by the tension maintained in the last finishing stands where the gage is so light that the loopers cannot be used, otherwise the section would run off the pass line. It is very desirable to have the control board of such design that the speed operator can reset the last two or three stands very close to the proper speed and at the same time watch the entry of the next strip. Unless this operation can be performed rapidly and accurately, variation in gage, width and camber can be expected.



Hot bed and transfer to plate finishing building.

The surface of the finished strip varies from a deep blue to the color resembling "red hard", depending upon the finishing temperature and the condition of the working rolls. Light tight blue oxide and drawing qualities do not go hand in hand, so the surface is a compromise, depending upon the amount of either one of these qualities that can be sacrificed.

For particular mill arrangement, there is usually a mill speed and finishing temperature for any gage which will produce a sheet with a good commercial surface and good forming qualities and which may be flattened without materially destroying any of these qualities. Proper attention is not given to these features frequently, with the result that a deep blue colored sheet is produced, but of such hardness that the surface is destroyed in the flattening operation by excessive skin rolling and roller levelling. In aggravated cases it may be necessary to resort to blue-annealing and pickling, in which case all the effort to produce a light tight oxide is lost.

In contrast to this condition, we have the case where the strip is delivered at a very high finishing temperature in order to get good drawing qualities. This necessitates the use of heavy drafts on the last finishing

stands, which, under these conditions, produce a sheet with a wavy edge. Where a good flat delivery is demanded, it is then necessary to resort to heavy skin rolling in the flattening operation, which may destroy the softness gained by finishing at the high temperature.

From observations made so far, it would appear that the battle is won when a properly conditioned slab is thoroughly heated, descaled and reduced to gage under ideal rolling conditions. This, unfortunately is not the case, as the disposal of the strip after the rolling operation frequently is a harder problem to solve than the actual rolling itself. The three methods most commonly utilized to dispose of the strip are: First—to coil the product in coilers or reels located at distances varying from 150 to 400 ft. from the mill; Second—to cut the strip into lengths of various multiples of the finished sheet on rotary flying shears located at the mill, the sheared pieces passing over several hundred feet of run-out table to suitable piler; Third—to transfer the long strip from the run-out table across a hot bed and cut it into short lengths at the hot bed or at shears located at the end of a run-out table from the bed. All modern broad strip mills are equipped with coilers and one or more shearing units, as it is not possible to coil and decoil the heavier gages without destroying the oxide.

Each method has its advantages and disadvantages and the location of the equipment has a very decided effect upon the softness and the ease with which the final sheet may be flattened.

Two modern coilers are usually able to handle the entire furnace capacity of the mill and operate comparatively free from interruptions when the mill practice is good and the thickness of the finished sheet is 16 gage and heavier. It is the writer's opinion that there is room for improvement in the machine when handling 18, 19 and 20 gage 30 in. wide and narrower.

When located near the mill, the coiler has the disadvantage that the material is coiled hot and therefore subject to considerable annealing, which is objectionable for certain classes of product. This annealing, however, is a distinct advantage on the lighter gages. If a cobble occurs in the coilers, it is a difficult job to clear the mill of the other slabs which have been partially rolled, without losing several of them. Coilers located 300 to 400 ft. from the finishing stand are not subject to the troublesome annealing feature on the heavier gages, but require very high delivery speeds to secure desirable annealing on the lighter gage sheets, and at times are unable to coil the strip at sufficiently high temperatures. They possess the advantage that that three or four strips can be delivered to the run-out table when a cobble occurs in the coilers and these strips can be rapidly disposed of after the cobble is removed. The roller can get a clear view of at least three hundred feet of the finished strip and is therefore able to produce a very straight section.

The flying shear is unquestionably one of the most important pieces of equipment in the broad strip mill, and its influence is so noticeable upon production and flatness that the proper location is a rather controversial question.

From a production standpoint, that is, ability to shear the strip as rapidly as rolled, the most desirable

View in coiler pit showing coil on transfer.

location is adjacent the last finishing stand. When so located the working rolls of stands No. 8 or No. 9 furnish the starting impulse for the flying shear and the working rolls in stand No. 10 act as the pinch rolls or measuring rolls. The shear will then crop the front end of the strip and cut the balance into multiples of the finished length ranging from 11 ft. to 22 ft. The shear can handle tremendous tonnages when so located, being limited usually by the heating capacity of the mill.

The operation of starting up the shear and synchronizing it with the mill requires rather complicated electrical equipment, comparatively large power in-put, considering the actual horsepower required to do the shearing, and heavy working pressures on the mechanical equipment involved. Miscuts may occur due to the failure of the shear to respond rapidly enough to variations in speed of the finishing stand, and bad cobbles may occur due to failure of the electrical control system.

When this method of starting and stopping the shear is not followed and the shear is run continuously there is always the possibility that the front crop end may be of such length as to give trouble on the run-out table; also the possibility of increased scrap due to the strip not cutting out properly.

Conveying cut lengths of wide strip over a wide run-out table at 1200 to 1500 ft. per minute without damage to the pieces or without interruption is not exactly a simple operation and necessitates cutting the strip into lengths that may be unwieldy in the finishing equipment. The section delivered from the mill, even though it may be of quite heavy gage, frequently is of such shape as to require a preliminary flattening when hot, otherwise it may be necessary to resort to heavy skin rolling in the flattening operation. The high rate of production, however, compensates for some of these difficulties.

A flying shear located at one side of the hot bed possesses the advantage that the strip may be given a hot

levelling, which is extremely beneficial on 16 gage and heavier sheets and is perhaps more beneficial as the gage increases, up to certain limits. This location has the disadvantage that the shear cuts at comparatively low speeds, that is, 450 ft. per minute and therefore curtails production to some extent. The annealing effect is not quite as good as when the strip is cut at the mill and piled as soon after as possible.

A roller leveller is usually placed on the hot bed when it is serving a flying shear located at a distance from the bed and is therefore able to do considerable hot levelling of the strip before the shearing operation. Strip so treated can be flattened more readily than strip which carries the mill shape until it has been cooled to room temperature.

This arrangement possesses the disadvantage that practically no annealing is secured in the pile of hot strip and some cooling strains are set up while the strip is being conveyed from the hot bed to the shears. The rolling operations are somewhat curtailed as compared with those where the shear is located at the mill. The principal benefits from this arrangement lie in the simplicity of the shear drive, freedom from breakdowns, ability to change knives while rolling coils and the ease with which the sheared sheets can be processed. Under favorable conditions two shears can handle up to 750 tons of sheet per eight-hour turn.

Any one of the above shearing or coiling arrangements lends itself to the production of a very satisfactory sheet or strip, and as previously remarked, possesses qualities whose value is debatable.

The processing of a sheet which has been coiled or sheared presents many difficulties even when produced under favorable mill conditions. In many cases the mill is operating under the pressure of a heavy backlog where the tonnage is secured at the sacrifice of flatness or even surface. Backing-up rolls which should be changed may be left in the mill for several days and finishing temperatures are boosted to avoid the possibility of annealing. Rolling schedules are arranged to suit the steel supply or delivery dates without regard to the ability of the mill to produce its best product. Under such conditions the finishing department is bound to encounter difficulties in the processing of the rolled sheet; but this condition is lessened by having such equipment as our modern decoilers, heavy skin rolls, backing-up roller levellers, rotary slitter and multiple shear units.

All of you are, no doubt, familiar with the smooth blue surface obtainable from a modern strip mill when operating under favorable conditions and have probably noticed the dead flat sheet that can be obtained by proper handling of a skin mill or a backed-up roller leveller. The lighter gages, especially, presents such a pleasing appearance that the strip mill operator has no fear of competition from the old hand jobbing mills. The accuracy of shearing which can be obtained from a rotary side trimmer and multiple end shear is almost uncanny when compared with the quality secured from the old conventional gate shear.

These features are not obtained as a natural course of events in the operation of a broad strip mill, but are secured by painstaking effort on the part of the entire personnel, starting with the highest plant executive and leading down to the sweeper in the finishing department. The burden placed upon the mechanical and electrical departments is especially heavy and the greaser on the mill is just as important as the roller when uninterrupted operation is considered.

There has been a tendency on the part of some mills to try to duplicate practices of an entirely different arranged mill and results have not always been satisfactory. Would it not be a more desirable procedure to standardize on a practice based upon the quality of steel made in your own open hearth furnaces and upon good rolling practices dictated by the equipment with which you will always have to work? Uniform steel quality and uniform rolling operations are unquestionably the secret of success of the modern strip mill. With these two features definitely established, the problem will be not so much what to do with the surplus capacity of the strip mill, as it will be where to find an outlet for the capacity of the old style sheet mills after they have lost a considerable portion of their present tonnage to the modern broad strip mill.

The subject of flat rolling of steel is so extensive that a paper of several hours' length could be written upon practically any of the features briefly mentioned this morning. The writer has always believed that more benefit could be secured from a paper by participating in a lively discussion of controversial matters, or by asking simple intelligent questions on points where information is desired, rather than by silently accepting or rejecting the author's viewpoint. With this in mind the present paper has been abridged with the idea of allowing sufficient time for a free and frank discussion of any of the problems mentioned in this morning's paper, and with the hope that someone in the audience might be interested in problems such as knowing just how much a slab could be squeezed without encountering difficulty in subsequent operations: Is there any benefit to be secured from plain cross-rolling as compared to spreading to width? Why will a slab with a

Run-out table, plate transfer and flying shears.

poor surface make a passable plate when rolled on a conventional 3-high plate mill and a rather poor second or reject when rolled on a modern broad strip mill? Is there any advantage or disadvantage in a universal roughing stand as compared to a detached vertical edger, and a plain 2-high or 4-high roughing stand? May we ask your cooperation in making this morning's session a success.

▲

DISCUSSION

PRESENTED BY

F. E. FLYNN, Gen. Supt., Warren District, Republic Steel Corporation, Warren, Ohio

R. W. GRAHAM, Asst. Supt., Plate Department, Carnegie-Illinois Steel Corp., Homestead, Pa.

C. L. McGRANAHAN, Supt. 76" Mill, Inland Steel Company, Indiana Harbor, Ind.

A. S. HELLSTROM, Engineer, Bantam Ball Bearing Company, Youngstown, Ohio

R. J. WEAN, President, Wean Engineering Company, Inc., Warren, Ohio

J. H. VAN CAMPEN, Chief Engineer, Republic Steel Corporation, 3100 E. 45th St., Cleveland, Ohio

H. D. ESTERLY, Electrical Supt., Alan Wood Steel Company, Conshohocken, Pa.

J. FARRINGTON, Electrical Supt., Wheeling Steel Corporation, Steubenville, Ohio

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Chairman Flynn: Mr. McGranahan, you are to be congratulated on that paper. It is evident you are a student of your work. We would like to have some questions asked. Mr. McGranahan, I am sure, would be glad to answer them. Are there any of these things in your mind that you would like to have cleared up in regard to the wide strip mills, mechanical or electrical? I think we have the man who can answer your questions.

R. W. Graham: I would like to express my personal appreciation of Mr. McGranahan's paper. I doubt that any of us here could add to or detract from the authorative work that he has given us. He has requested that we ask him questions on topics that might merit more detailed discussion.

Mr. McGranahan made a remark which indicates that the surface troubles increase as the finished gage increases. I would like to ask him how this effect is related to the quality and type of slab conditioning, and if there is any noticeable difference between flame conditioning and the old type of chipping on the product rolled in this type of mill.

C. L. McGranahan: Our experience with flame conditioning on slabs has been rather limited, although we have conducted some experiments with it. On a heavy plate, I would say flame conditioning would produce a fairly satisfactory plate if rolled on an ordinary 3-high mill. If rolled on a modern plate or broad strip mill, the surface you secure is so far superior to that produced upon the conventional plate mill that all the defects are magnified to such an extent that a little scab or sliver, which you would never notice at all on a product made in the old plate mill, will stand up very conspicuously. The reason for this is that on the conventional 3-high reversing mill you will take about nine passes, with a plentiful use of salt, to get it down to the gauge which you could ordinarily secure on leaving the No. 4 roughing stand of a broad strip mill. In the reversing operation of the 3-high mill there is a tendency for these defects to stand up, and they are broken off. On a straight-line, continuous operation, they are merely lapped over and the scale sprays do not get a chance to remove them. The result is that when the plates get into the finishing department, the defects are very easily picked out. Unless extreme care is used in the conditioning of the slab, you may run anywhere from 15 to 40 per cent rejections when using steel on which you would probably not run over 5 per cent rejections if rolled on the old plate mill.

When you are using the scarfing method of conditioning, it is almost impossible to completely eliminate seams. There is a tendency for the flame to heal these over. On a considerable tonnage of work this feature is not objectionable. However, if the slab is to be reduced on the hot strip mill to a band suitable for cold reduction to say 20 gauge, the defects will probably be unnoticeable until the sheets get to the inspection department where they are rather evident.

The practicability of flame scarfing is determined by the remark which I made early in this paper; that is, by weighing the rejections at the customers' plants against the economies that are to be effected by flame scarfing. On a considerable number of products flame scarfing is very satisfactory, but we are approaching the subject in a very careful manner. Our tests have indicated that if we chip a scarfed slab, the defects have not been entirely removed.

A Member: I would like to ask if there is any improvement in the forming of all these sheets from a full transverse rolling; that is, rolling the slab full length transverse in addition to the natural spreading.

C. L. McGranahan: We have not been able to detect any appreciable increase in drawing qualities or other beneficial effects that might be secured along that line, but on material that has spread to width, you do get some erasing out of the defects put on the slab by the manipulators at the blooming mill, if the slab is produced on a blooming mill. In other words, they are usually lengthwise of the slab, and in the cross-rolling operation those are spread out.

As far as the drawing properties of the sheet made by straight-away rolling as compared with true cross rolling, I do not believe there is any benefit, except in the very extreme high carbon ranges. When you get

up around 85 carbon, 85 manganese, for specialized work, there is some benefit to be secured. Naturally in a broad strip mill designed for cross rolling only for width, cross-rolling curtails your productions as much as 40 or 50 per cent, because you have a comparatively narrow slab to start with. If you are rolling a narrow section, you do not get much tonnage.

R. W. Graham: Mr. McGranahan, you made a remark about clean cooling water. Am I to assume you have found that dirty cooling water, reasonably dirty as most mill water is, has an effect on surface?

C. L. McGranahan: The importance of cool, clean water is usually manifested by the condition of the working rolls in Stands No. 5, 6 and 7. You are carrying a comparatively heavy section into those mills and, unless you have a very adequate supply of cool water, reasonably clean we will say, the rolls build up to such a high temperature that you lose the smooth surface. It wears away very rapidly, as there is a tendency for the roll surface to fire-crack. With clean, cool water you might get 500 tons, but with water around 140 degrees you would only get about 300 tons.

It is desirable to have clean water because, unless steam or something else is used to blow the impurities off the top of the strip, they will be rolled in. Granulated slag is especially objectionable. Unless the water is reasonably clean, the cooling sprays on the rolls will clog up and there will be unequal cooling of the roll, which will naturally change the true shape of the roll and there is a possibility of having a section delivered from that particular stand which will not behave properly in the next stand.

Fortunately, being located on Lake Michigan, we have a very adequate supply of clean, cool water.

A. S. Hellstrom: I would like to have the question discussed as to whether there is any advantage in the universal type mill over the detached edger type.

C. L. McGranahan: That is a question I merely offered as a suggestion, trying to get the boys to ask questions. As I stated in my paper, there are so many features that should be discussed that have never been discussed, that I brought that out as a lead.

A. S. Hellstrom: I am very much interested in it and would like to hear what you have to say.

C. L. McGranahan: Each one possesses advantages. The universal mill possesses an advantage in that it is a very compact arrangement, requires a minimum amount of moving parts, and cuts down the number of table sections. It also has a very beneficial effect in making an entry into the next mill by pushing the bar into the working rolls when you are carrying a fairly heavy thick bar in the roughing stands. The working rolls are usually of a diameter ranging from 20 inches to about 26 inches, and when taking up to 35 and 40 per cent draft, the angle of the bite is such that there may be a little hesitancy about making a good entry. In such case you are liable to break the working roll spindles. When you have the bar in the vertical rolls of a universal mill, it is pushed into the horizontal roll. This type of mill possesses a disadvantage in that you have to watch your schedule clerk carefully, as he is very liable to schedule a blank which is to be cross-rolled and which will be shorter than the distance from the vertical rolls to the working rolls.

At Inland it is 72 inches from the vertical rolls into the working rolls, and 67 inches is the minimum slab we can roll cross-ways and get into our No. 2 Mill. It took about a year to finally educate everyone in the strip mill order department that a 60 inch slab would lay up between the vertical and horizontal rolls and you would have an unwieldy cobble to remove. A detached vertical edger has the advantage that it is possible to use considerably larger diameter of rolls. You can have a larger horsepower in-put into the mill and are thus able to get a greater amount of edging than you can in the universal mill.

With the universal mill, on any material not involving cross-rolling, it is not a difficult matter to keep within commercial tolerance of nothing under and a quarter inch over in width. On cross-rolling it requires very painstaking efforts. With the detached edger, there is less liability of stretching the piece between the vertical mill and the horizontal rolls, due to variation in speeds. It is possible to throw a little loop in there, if necessary. It requires very close synchronizing of these rolls in the universal mill.

R. J. Wean: In visiting some of the strip mills and in listening to Mr. McGranahan's paper, I have observed that the mills cut their strip many times in 20 to 24 foot and even 30 foot pieces and run at 1000 or 1200 feet a minute, pile it and later cut into smaller sizes. That seems to me to be a very uneconomical procedure from the standpoint of scrap.

I didn't understand from Mr. McGranahan's paper that there was a good reason, or what the reason was, for courting this high scrap loss by cutting it into 24-foot pieces and reshearing, instead of coiling and then shearing from a coil.

C. L. McGranahan: It is quite practical to coil from 13 gauge to 20 gauge, decoil it and get a fairly tight oxide, especially if you resort to skin rolling. For a great many classes of work, the coil breaks which result when you decoil 13 gage and heavier, are very objectionable. When you are skin-rolling these gauges, the skin-roll operator gets a chance to see only the ends, with the result that unless there is almost perfect hot roll practice in every coil, you will find a half dozen sheets which have a wavy edge. This necessitates either taking these sheets out of the finished pile and subjecting them to an additional skin-rolling operation, which hardens them further, or sending them to the customer and accepting a complaint.

I would say that the tonnages heavier than 13 gage which cannot be coiled and decoiled are relatively large compared to the tonnages that can be coiled. In other words, the amount of tonnage for flat work is so great, when you get up into the higher carbon ranges, that decoiling is questionable. There is doubt in my mind as to whether or not these requirements can be decoiled and flattened to make a satisfactory delivery out of the sheet, even though there are no surface or flatness requirements. I do not know of anyone yet who is decoiling from a processing machine, or even skin-rolling straightening and cutting to length,

sheets of .18 to .22 carbon broad strip. (NOTE: This is being done very successfully in the narrower widths up to .28 carbon.)

R. J. Wean: Then my understanding of your answer is that higher carbon steels and heavier gauges are the ones that you would prefer to cut into the short lengths?

C. L. McGranahan: Yes. It would seem that 14, 16, 18, 19 and 20 gauge materials are ideal sizes to coil and decoil with the processing machine or by skin-rolling, straightening and cutting to length, and the heavier gauges then should be cut upon a flying shear.

I quite agree with your contention that at times there does appear to be a loss due to cutting strips to long lengths and then shearing them to shorter multiples in the finishing. The actual scrap loss involved, however, is perhaps not greater than when you take them across a hot bed and then put them into a flying shear. In other words, you are cutting a 10-foot length with one inch scrap in one case and a 30-foot length with three inch total scrap in the other.

It is a rather difficult job, however, to process a sheet much longer than 180 inches in length and when you get up to a sheet 240 or 300 inches in length, it is frequently necessary to cut it into a shorter multiple, give it a semi-finishing operation, and then finally shear it on the gate shear.

In my discussion of the flying shear located at a considerable distance from the mill, I made mention of the fact that the piece cut is of such size that it can be readily processed. It varies between the limits of 90 inches and 190 inches. In handling a sheet of that size, it is possible to get a very excellent production on any of the shearing equipment mentioned in this paper.

A Member: I would like to have brought out in greater detail the draft reduction and the tendency for over reduction.

C. L. McGranahan: It is, of course, necessary to resort to heavy drafts in the roughing stand where you are starting with a comparatively narrow slab such as we get at Inland, that is 41 inches in width. We go up to 47 per cent draft at times on our No. 1 Stand.

The temperature of the bar and the thickness is such that we have not been able to notice any serious effects from such drafts as that.

In putting the spread slab into the squeezer, you have to use extreme caution in the amount of squeezing that you do on it, otherwise you will get a bulbous section. I mean a section which is thicker at the edges than at the middle and which produces long ears or fish tails when rolled through the remaining roughing stands. I have seen ears 15 feet in length pulled out due to faulty operations in these stands.

By resorting to heavy drafts in Stands No. 2 and 3, you are very liable to fire-crack the rolls. At the same time you are liable to tear the surface of the section and if you do that, you will get slivers. If the heating is 100 per cent perfect, you are able to use very heavy drafts and get away with it, but if the steel is underheated you are liable to run into extreme difficulty.

There is a temperature at which the steel will flow fairly uniform throughout the piece. If the temperature of the slab is such that that condition doesn't prevail, there will be a non-uniform flow. The surface of the steel, due to the cooling water and the temperature of the rolls, naturally has a tendency to chill, and you have a very aggravated condition and the surface tears. I have seen cases in which you could see needles standing up all over the slab, due to excessive drafts and the use of fire-cracking rolls. I question whether such drafts or the use of fire-crack rolls is economy.

J. H. Van Campen: I would like to ask Mr. McGranahan whether there is any noticeable difference when inspecting strip steel where the slab is rolled continuously in one direction against a slab that has been cross-rolled in order to obtain necessary width in the broad side mill, and then rolled in one direction to the finished product.

C. L. McGranahan: We have not been able to determine any appreciable increase in quality when spreading for width as compared with straight-away rolling. As I remarked in answer to one of the other gentleman's question, the principal benefit is that you are able to erase some of the surface defects which might be caused, such as, manipular scratches or side-guide scratches in the blooming or slabbing operations. You actually do erase some of those. If they are not erased in straight-away rolling, there is a tendency for them to lap over, and you will then, of course, encounter difficulty at the final inspection of the hot or cold rolled sheet. It shows up as a little hair-line and is frequently a very hard defect to analyze properly.

I have never seen anyone yet who could definitely state whether such a defect is a scratch from the manipulator, a scratch made in the hot mill, or a particle of dirt from the scale removal water.

J. H. Van Campen: I wasn't thinking so much of the angle of surface of the finished product as I was of the metallurgical angle. It seems true that in straight-away rolling the interior defects such as porosity and inclusions tend to follow the center of the slab. In cross-rolling or spreading the slab, the tendency would be more to spread these defects over a greater area and width. I wonder if that has any bearing on the quality of the finished product.

C. L. McGranahan: On good quality of steel I believe there wouldn't be very much, although it is possible that if you have skin blowholes or surface defects of that sort on the slab, there might be a tendency on the cross-rolling to spread those out and have them take up a greater width. It takes about 35 seconds longer to cross-roll a slab than it does to roll it straight-away. You are naturally losing temperature on the cross-rolling operation. There might be more healing up of the interior defects in straight-away rolling as compared with the cross-rolling operation.

A Member: What defects on the wide strip mill are attributed to the tendency to telescope in the coilers?

C. L. McGranahan: The important thing in the op-

eration of the coilers is to see that the coiler is kept in good mechanical condition. The abrasion on the rolls and on the mandrels, when rolling light, thin sections is rather excessive at times.

With a coiler in good mechanical condition and proper harmony existing between the finisher, that is, the man in control of the screws on the last finishing stand, and the speed operator, it is possible to produce a very straight section from the mill. When such a section is put into the coiler there is a traveling back and forth or telescoping going on during the coiler operation, of an inch to two inches, and when the coil is ejected and put into the transfer or receiving stand, proper manipulation of the coiler will have loosened the coil sufficiently so that it will telescope back into a good condition.

When proper harmony is not existing between the speed operator and the finisher, you will get a bar out of the mill which resembles your golf drive, that is, it hooks and slices. When it gets into the coiler, it is bound to aggravate the telescoping condition.

On the particular type of coilers which are installed at Inland, the strip is wrapped around a large mandrel. When the mandrel roll, or the mandrel itself, becomes worn, there is a tendency for the strip to travel back and forth on the mandrel. The heavier the weight of the coil, the more aggravated the condition becomes, because you do not have enough space then to recoil the strip in the coiler and get the desirable looseness. We do not experience any difficulty with the wider coils. We have found that the telescoping starts to become aggravated at 16 gauge, 30 in. wide and narrower, or 18 gauge, 33 in. wide and narrower. When this section gets down to 19 gauge, 20 in. wide, operations are curtailed considerably due to cobbles in the coilers.

I might state, that it requires extremely careful operation and cooperation between the rolling crew to produce a straight coil in the lighter gauges, and it is imperative, if you are to avoid telescoping, that they do this. I do not know of any coiler on the market that does not produce telescoped coils in the lighter gauges.

These telescoped coils, if not aggravated, should not cause any appreciable amount of inconvenience in the finishing department if they will face the problem from the standpoint that the hot rolling department is endeavoring to give them the maximum weight obtainable in coils and that the condition can be corrected or practically eliminated if you start with a slab smaller.

The condition is very pronounced on 16 gauge when rolling a 4700 pound coil, say 30 wide, as compared with a 3500 pound coil, 30 wide. The inconvenience should be weighed against the economies; that is, the lesser number of ends and the greater tonnage output of the particular finishing unit involved.

H. D. Esterly: Is there any relation between the speed of the mill and the surface of strip for different gauges?

C. L. McGranahan: There are a number of factors entering into the surface as determined by the speed of the mill. Naturally, if you want a high finishing temperature, you run the mill at top speed.

As I brought out earlier in this paper, for every gauge and for every mill arrangement there is usually a speed and temperature which will produce a good commercial surface and you will get good forming qualities from the product. If you want to get greater forming qualities, you naturally will increase the speed of the mill; in other words, make a hotter delivery. If the delivery speed is increased and the temperature is high enough, there is a possibility of a third scale raising up somewhere in the finishing stands where it is impossible to use a hydraulic spray to remove it on account of the necessity for looping. Under such conditions, you are naturally carrying a very heavy bar toward the finishing end of the train. To reduce that bar down to gauge, you are putting heavy work on two or three stands. You are overworking those stands and submitting the rolls to a higher temperature than they normally would be subjected and they consequently lose their surface more rapidly than if you were finishing at a lower temperature.

J. Farrington: I would like to ask whether you would recommend coiling the strip tight or loose as it comes from the finishing stand.

C. L. McGranahan: We normally operate our coilers about 100 feet per minute faster than the delivery speed. There are two reasons for this. One is to maintain the tension about which you are speaking. The other one is to permit us to slow the strip down, make a slow entry into the coiler when rolling the lighter gauges, then speed it up and take it away as far as we can.

J. Farrington: Do you notice more tendency to telescope the coiler when you coil tight?

C. L. McGranahan: No, we prefer to run with a tight strip.

FLAT ROLLED STEEL PRODUCTS

PROCESSING FOR AUTOMOTIVE INDUSTRY

By R. J. WEAN, President
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Paper presented before the A. I. & S. E. E. Convention, Pittsburgh, Pennsylvania. September 24, 25, 26, 1935

▲ THE PROCESSING of flat rolled products might be defined as the subsequent treatment of an initially hot rolled flat steel product so that it may be properly prepared for its final use. The multiplicity of treatments for flat products is so great that rarely are they all available in a single plant. One need only consider the use to which these products are put to realize the importance of the processing treatments in any plant. I will briefly mention a few of the uses.

Steel barrels or drums for oil, grease, paint or alcohol. Also, there are steel products for other types of containers and utensils, all made of material in sheet gauges.

Under the *enameled group* we have highway signs, display cabinets, display signs, license plates, washing machine tubs, kitchen sinks, kitchen cabinets, bath-tubs, refrigerators, air conditioning units, soft drink vending machines, stoves, wringers, ironing machines and many other similar items that come under the enameled and lacquered group.

Under *common grades of sheets* there are the single pickle, one-pass cold roll, box anneal galvanized, long terne, "Galvanneal" and similar grades.

Electric sheets constitute another group. These sheets are used for transformers, armatures, control equipment, etc., and constitute a highly specialized group of products.

Under *alloy sheets* there are various types and analyses of stainless, heat resisting, etc. and this group requires a high degree of specialization.

Auto body or full finished sheets include:

*Frame Stock	*Oil Pans
Fender "	Doors
Hood "	Back Panels
Radiator Shells	Side "
Front Panels	*Gas Tanks
Running Boards	Turret Tops

**Automotive parts, but not full finished.*

R. J. WEAN

In speaking of the processing of flat rolled steel products, one can hardly avoid the mention of such things as the verticle tube type annealing furnace, strip normalizing furnaces and abrasive cleaning machines for regulating surface conditions, but as each of these is a subject requiring its own treatise, we will confine our present paper to problems in connection with surface strains in automotive sheets and strip steel.

The requirements for any particular design of automobile are not extremely varied and severe but the particular grade of sheet required for the part in one car may vary for the same part in another make of car. For instance, in the case of fenders, one design of car may need an extreme drawing quality and depend entirely upon its design and shape for strength while another may require a greater hardness for strength with a minimum draw requirement. Similar comparisons could be made of any other parts. Few, if any, of the automotive companies specify the treatment their products should have. Generally, highly skilled sheet specialists study the parts to be made and by trial and experiment develop their treatment and process. The producers must have the best facilities available as it requires no prophet to foretell what will happen to a producer who makes a good initially

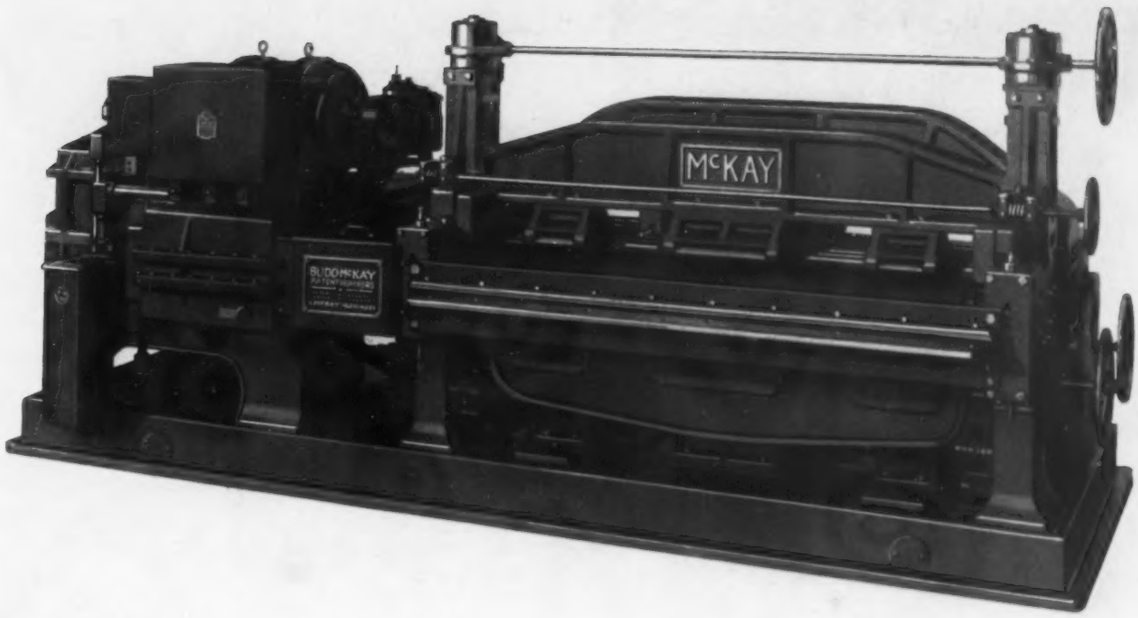


Illustration shows Budd-McKay sheet processing machine.

hot rolled product but spoils a large part of it either through improper facilities or lack of knowledge as to the treatments required.

One of the greatest problems in connection with sheets for auto body purposes is what is known as "stretcher strains". In some instances, these surface irregularities are called "wormy metal" and are exceedingly objectionable, particularly where the surface of the sheet in which they occur is to receive a finish or polish such as for any part of the body, hood or fender of an automobile where such blemishes are quite noticeable. These stretcher strains generally reflect an improper treatment or are the result of aging between the time the material was finished in the mill and the time it was stamped or pressed. The removal or prevention of stretcher strains has been given thorough and endless study by research engineers, metallurgists and production men in the automotive field. It has been known for a long time that roller levelling will overcome a slight tendency to stretcher strain but the effect of this light cold working is lost if the sheets are not drawn immediately after the roller levelling operation. Since cold working improved the steel, the problem was how to cold-work the material excessively and not decrease the ductility of the steel.

The problem was attacked by many; however, it is quite evident that the most progressive and best work was done by the Edward G. Budd Manufacturing Company and The McKay Machine Company. Their efforts were combined and resulted in the development of what is known as the Budd-McKay patented processing machine.

At this point I would like to quote a paragraph from a joint paper by Joseph Winlock and Alfonso E. Lavergne read before the American Society for Steel Treating in 1931,—"It would seem that most low carbon steel is best suited for deep drawing purposes when it is in the semi-plastic condition since it can be deformed at a faster rate without premature fracture taking place and since no stretcher strains form when the steel in this condition is deformed".

It is interesting to note how clearly and positively the inventors of the machine shown in Illustration No. 1 followed this line of thought in the development of their machine. I quote from one of the patents:

> "When metal is cold worked in mass far beyond the limit of its elasticity for a period of some hours duration after being so worked it shows no yield point in its characteristic curve, this curve being of regular outline all the way up to the point of ultimate strength. Coincident with the changes in elasticity characteristics brought about by this cold work or overstrain is a change in the elastic properties of the metal until a point approaching a disappearance of the yield point is reached where the metal partakes in general of that characteristic known as "cold plasticity". Always when material is relatively in this general state of cold plasticity, the occurrence of stretcher strains is precluded altogether. By introducing initially this characteristic of cold plasticity, it becomes possible to work the metal to a sufficiently high degree and yet give a roller leveler its full chance to straighten out the corrugations resulting from the cold working at the same time it straightens out the ordinary surface irregularities for which the usual leveling operation is intended. The greater the degree to which the working for cold plasticity is carried out, the longer the period of reversion during which the metal may be stamped without the formation of stretching strains or worms".

The machine in Illustration 1 is so designed as to mechanically manipulate the sheets including the bending and progressive advancement of the bend throughout the area of the sheet, and the subsequent roller leveling or straightening operation permits a heavier or more secure initial working action on the sheet than would otherwise be possible; that is, permits the bend-

Illustration 2A shows an auto body sheet, box annealed at the last operation. Note heavy stretcher strains.

Illustration 2B shows a full finished sheet which plainly shows age strains indicating material on hand for some time

Illustration 2C shows a full finish sheet fully processed by the Budd-McKay machine. Note steel rendered free of strains.

ing to be carried beyond the limit of elasticity of the metal and this results in greater freedom from the surface irregularities known as "stretcher strains" and the work is carried on to such a degree that reasonably permanent results are obtained in the sheet, permitting this operation to be done some length of time ahead of the actual press operation. There are machines of this type, either in operation or under construction.

Recently, an official of a large auto body producing company in a newspaper interview stated: "If we were to attempt to draw and form one of the new turret top roofs—or, for that matter, a body panel—from the steel as it comes from the mill, it would be wrinkled, rough and in many cases would tear due to variation in the physical strength of the grains". He stated that to avoid this, every piece of sheet steel they use is run through a machine that kneads the metal in much the same manner as a baker kneads bread dough. As a consequence, the sheet is ductile and behaves uniformly when placed in the giant presses that shape the various parts of the turret top and body.

Illustration No. 2 is made up of three photographs. *Illustration 2-A* shows an auto body sheet which has been box annealed after the last operation. The heavy stretcher strains are plainly visible. *Illustration 2-B* shows a full finished sheet which plainly shows age strains indicating that the material has probably been on hand for some time. *Illustration 2-C* shows a full finished sheet fully processed by the Budd-McKay machine. Note the uniformity of surface and that the steel has been rendered free of strains which was accomplished without impairing its original drawing qualities.

One can only speculate and wonder as to how long it will be before this knowledge and the things learned by the use of equipment in the automobile field will be applied to other grades of stampings and pressed articles.

From knowledge gained in the development of the flat sheet processing machine, it became possible to develop a machine to apply to strip steel. Here, the principal problem is to prepare the strip so that it will not fracture or develop cross-breaks prior to its subsequent processing. If the hot rolled strip steel is first properly coiled, and its first uncoiling is through what is known as a "processing uncoiler", permitting the uncoiling of the strip free of any cross-breaks except those that may have been placed into the coil prior to the uncoiling, the steel will be worked to such a state of cold plasticity that the uncoiled material will not break or flute in subsequent forming operations unless it has been subsequently annealed.

Uncoilers of this type as shown in illustration 3 are being used for the processing of coils of hot rolled strips directly from the mill, properly treating same so that the material can be used for barrel stock and other formed parts without fluting or cross-breaks.

One of the most desirable results in connection with strip steel is to have a hot rolled strip uncoiled free of cross-breaks so that when it is cold reduced for auto body sheets these marks will not be visible in the fin-

ished product, for as sure as the cross-break exists before the strip is pickled and before cold rolling, it will also exist in the finished product and will show up in the press operation very much the same as a stretcher strain. While there are ways of overcoming these strain marks after the product has been cold rolled, they are costly and the treatment is generally one that decreases the drawing quality of the product. In time, probably all hot rolled strip will be uncoiled in this type of equipment and placed into this state of cold plasticity, as there certainly can be no merit in continuing to place undesirable and objectionable cross fractures in the material when they can be eliminated. Customers' specifications will ultimately make it impossible to dispose of material having these objectionable features.

Since cold plasticity can now be imported to both sheet and strip material, it is quite likely that numerous products can be made from hot rolled material that heretofore have required other finishing treatments. The production of barrel stock is a perfect example. Under the old method the material was sheared, box annealed, skin passed on a cold mill and re-squared. Under the new method it is uncoiled through a processing uncoiler and sheared to size. The savings are obvious.

The same principles applied to other pressed or formed articles can not help but show similar economies and it is in this manner that the strip steel producers will find outlets for the large strip capacity now being installed. The processing of wide strip steel will bring its own particular developments and problems and the solution of these will be a challenge to all members of this Association.

Illustration 3 shows uncoilers used for processing of coils of hot rolled strip.

DISCUSSION

PRESENTED BY

C. L. McGRANAHAN, Supt. 76" Mill, Inland Steel Company, Indiana Harbor, Ind.

R. J. WEAN, President, Wean Engineering Company, Inc., Warren, Ohio

F. E. FLYNN, Gen. Supt., Warren District, Republic Steel Corporation, Warren, Ohio

C. L. McGranahan: I would like to ask Mr. Wean if the surface of the ordinary hot rolled sheets after decoiling is sufficiently free from cross-breaks for the usual flat work. Can it be coated with paint to present a pleasing appearance?

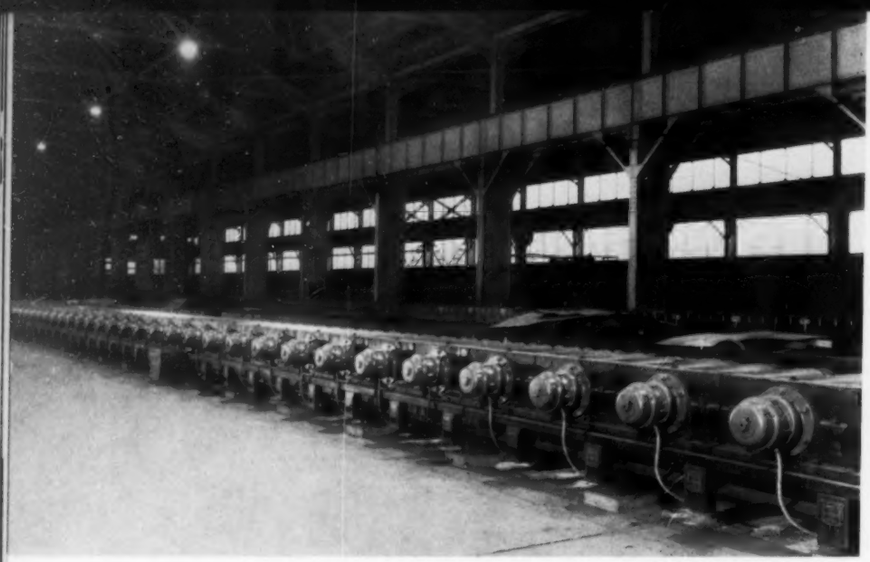
R. J. Wean: Mr. Frank Flynn, the Chairman, probably can answer your questions more fully than I; however, in my opinion, if the strip comes from the mill at a high temperature and is coiled tightly before cooling, to a certain extent, the surface of the strip seems to receive a deoxidizing action which results in the strip having a very tight scale and a surface condition highly satisfactory for use in the manufacture of steel barrels, drums and similar products. In fact, the strip has all of the appearances in many ways of what is known as a blue annealed cold rolled steel product.

The ability to produce this type of coil depends largely on the temperature of the material leaving the mill and the coiling of the strip tightly before there is any great loss of temperature. This, of course, depends on whether the coiler is up near the last mill stand or whether it is 200 or 300 feet from the last stand.

In my opinion, most strip mills will eventually equip their runout tables with at least two coilers—one near the last stand for coiling material at high temperatures to produce material on which they wish to have a very tight scale and which will probably be sold in many instances without pickling. For material that is to be pickled and cold reduced, the coiler will be located at some distance from the last stand, for on this type of material it is not desirable to have a tight scale and in fact for the pickling operation it is of advantage to have the material coiled at a lower temperature and permit the surface to have a loose scale.

Chairman Flynn: Does anybody else want to ask Mr. Wean a question?

If not, Mr. Wean, we want to thank you for that paper. There is a lot of good practical experience in there. Mr. Wean is really a help to the operating departments of the mills of the country.



INDIVIDUAL MOTOR DRIVES

FOR RUNOUT TABLES AND COILER ROLLS

By W. B. SNYDER and L. E. HILDEBRAND
General Electric Company

Paper presented before the A. I. & S. E. E. Convention, Pittsburgh, Pennsylvania, September 24, 25, 26, 1935

▲ THE SUCCESSFUL performance of the electrical equipment—representing an investment of from $100,000 to $400,000—associated with the runout tables and coilers of the modern strip mill, contributes in no small measure to satisfactory and profitable mill operation. The most careful engineering study is warranted to insure that the maximum useable performance and economy is designed into the drives. The component parts of such drives are all well known; and the designer's problem, therefore, becomes one of selection and co-ordination in choosing the units which, in combination, produce the best results. Like the modern automobile, the modern runout table drive should be built as a unit and not assembled.

While all runout tables at times run continuously at full speed, at other times they must operate on duty cycles of frequent and rapid acceleration and deceleration. The latter type of operation is always the limiting one in the selection of the electrical apparatus. Such a cycle imposes two problems on the drive: (1) To develop sufficient torque to meet the desired time of operation, and (2) to be capable of handling the energy requirements without undue heating.

ELEMENTS OF TABLE AND COILER DRIVES

The elements of a table or coiler drive are as follows: Squirrel cage induction motors are used exclusively as the individual drives of the rolls, for two reasons: First, their low first cost and simple construction render them the least expensive to install and maintain; second, since the motors are supplied from a common power source, the roll speeds are automatically matched. An adjustable frequency set consisting of an alternator driven by an adjustable speed DC motor is provided to operate the roll motors over a speed range of 3 or 4 to 1. If dynamic braking is to be employed, a low voltage DC generator with a suitable drive is required to furnish the necessary excitation. Magnetic control is provided to give smooth and rapid operation of the table or coiler, and to furnish proper protection to the rotating apparatus.

While the first requirement of a runout table or coiler drive is that it meet the desired operating duty cycle, a satisfactory drive must do more than this. It must operate continuously with a minimum of mill delay, and with low maintenance expense. The losses on the operating cycle must be kept low, not only to save power, but because additional losses in the equipment increase the possibility of failure. The first cost should be as low as is consistent with the factors just mentioned. Such a drive can be obtained only when the three elements—motors, set and control—are properly matched and combined into a unified equipment.

TYPES OF MOTORS

Three types of squirrel cage motors have been widely used as the individual drives of runout table and coiler rolls. These are: (a) The normal low resistance squirrel cage motor; (b) The motor with a moderately high rotor resistance, sometimes known as the semi-high-torque motor; and (c) The true high resistance, or high-torque motor. The performance of these motors over a speed range comparable with that of a table or coiler drive is shown on the following curves. These are all based on motors of the same frame size, and the same value of dynamic braking excitation is maintained throughout.

Fig. 1 shows the characteristics of the three types of motors *at maximum frequency and voltage*. The two

speed-torque curves from plugging to synchronous speed shown for each motor may require some explanation. The dotted curves probably have a familiar appearance, as they are the ones obtained by the ordinary methods of calculation, and the ones commonly used to illustrate induction motor performance. The solid curves more nearly indicate the torque obtained by actual dynamometer tests.

A comparison of the three sets of curves in Fig. 1 shows that at maximum frequency, the normal motor has the highest starting and plugging current, the lowest starting and plugging power factor, and the lowest starting, and plugging torque of all three types. Its average dynamic braking torque is low. It also has the highest loss on acceleration or deceleration, as will be brought out later. It is thus the poorest motor of the three for starting from full voltage, and for plugging or dynamic braking from top speed. Under full speed running conditions, however, it has the best efficiency, power factor, and speed regulation of the three types, and thus is the best of the three for normal running duty. The curves also show that the high-torque motor is the best of the three types for starting and stopping duty. It is the poorest of the three types for continuous running duty.

The semi-high-torque motor shows intermediate performance. Its running characteristics are almost as good as those of the normal motor, and its starting and stopping characteristics are somewhat better.

Fig. 2 shows the same three motors operating at *two-thirds frequency and voltage*. The maximum torques of all motors are somewhat reduced, and all motors show improved starting and stopping characteristics, and somewhat inferior running characteristics. The normal motor is approaching the full frequency characteristics of the semi-high-torque motor. The semi-high-torque motor at two-thirds frequency is approaching the full frequency characteristics of the high-torque motor.

The behavior of the same three motors at *one-third frequency and voltage* is shown on Fig. 3. Here the tendencies indicated in Fig. 3 have become still more pronounced. The performance of the normal motor is approaching the full frequency performance of the high-torque motor. The high-torque motor has developed such a high slip that its average accelerating torque is low and its horsepower output is severely limited. The characteristics of the semi-high-torque motor are still intermediate to those of the other two.

The points of interest on the three sets of curves may be summarized as follows:

1. On normal running duty, the normal motor shows the best performance of all three types, regardless of frequency.
2. As the frequency is reduced, all types of motors become progressively better for starting and stopping, and poorer for running, and at low frequency, the normal motor develops excellent starting and stopping characteristics.
3. The application of dynamic braking at top speed produces a low average value of torque with a high peak. The plugging torque at full frequency is roughly constant. Thus, for the same value of maximum torque, the motor may be plugged to rest from full speed more rapidly than it may be stopped by dynamic braking. Or, for the same stopping time, the motor, if plugged, will make fewer revolutions, indicating shorter travel of the metal on the table, than if stopped by dynamic braking.
4. As the frequency is lowered, the average dynamic braking torque increases, while the peak remains the same. Thus, dynamic braking becomes more efficient as the frequency is reduced.

METHODS OF OPERATION

Several methods of starting and stopping table and coiler motors are in common use. The two chief methods of starting are as follows:

(a) By connecting the motor to full frequency and voltage.

(b) By connecting the motor to minimum frequency and voltage, and then accelerating to full speed by bringing the adjustable frequency set up to top speed and frequency.

The three common methods of stopping are:

(a) By plugging from top speed.

(b) By dynamic braking from top speed.

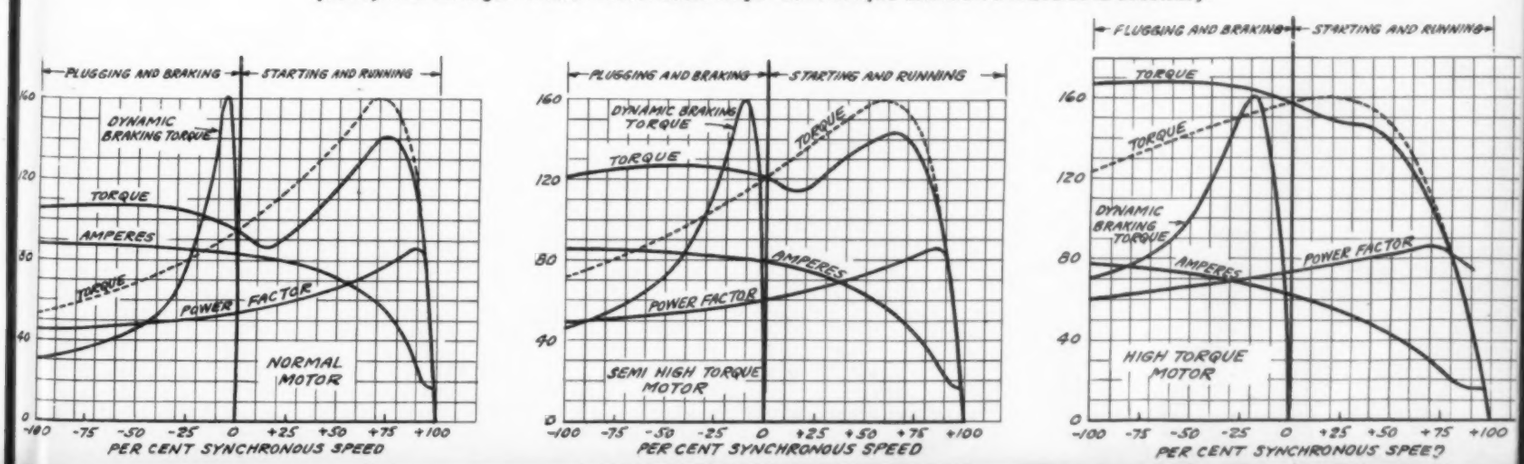
(c) By a combination of regenerative braking to some low speed, and then braking to rest.

In the remainder of this paper, acceleration and deceleration by change of frequency and voltage will be called "frequency control."

ACCELERATING AND DECELERATING LOSSES

Before considering the selection of the electrical apparatus for a table or coiler drive, let us digress a bit into induction motor theory. It is well known that the kinetic energy stored in a drive represents a fundamental unit in problems of acceleration and decelera-

Figure 1—Typical characteristics of squirrel cage induction motors operating at full frequency and voltage. Power factor scale in per cent torque and current scales is arbitrary.



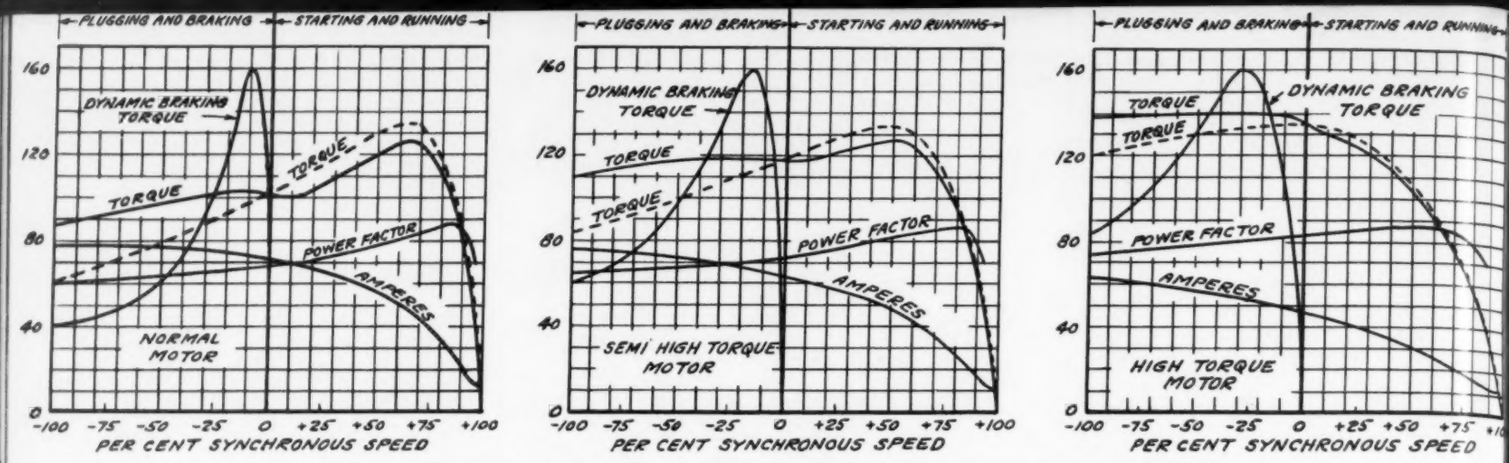


Figure 2—Typical characteristics of squirrel cage induction motors operating at two-thirds frequency and voltage. Power factor scale in per cent torque and current scales is arbitrary.

tion. Each time a motor is started by connecting it to a constant frequency bus, or stopped by dynamic braking, one of these units is dissipated as heat in the rotor. Each time it is plugged to rest, three units are similarly dissipated. This rotor loss is constant, regardless of the kind of motor. There is also a similar loss, varying considerably with the type of motor, in the motor stator. These losses due to acceleration and deceleration are in addition to the normal running losses of the motor and, on frequently repeated cycles, are many times the running losses. It is not so widely appreciated that if an induction motor is accelerated or decelerated by raising or lowering the applied frequency, the motor is really operating under running conditions, and the only losses are those incident to normal operation.

Table I shows the relative magnitudes of the stator and rotor losses of the three types of motors for the several methods of starting and stopping, when operating over a 3:1 speed range. The unit in which the losses are expressed is the kinetic energy in the drive at ⅓ speed.

Comparing cycles A and B for any of the three types of motors, we see that the losses on the starting-dynamic braking cycle are only half those on the starting-plugging cycle. Comparing cycles A and C, or B and D, we see that the losses on the "frequency control" cycles are only a fraction of those of the other comparative cycles.

Also, as we would expect from the motor characteristics, on cycles A or B the normal motor shows the highest losses, and the high-torque motor, the lowest. On cycles C and D just the reverse is true. The normal motor shows the lowest loss, and the high-torque motor, the highest. Furthermore, if we take into account the losses incident to full speed running, the comparison is still more favorable to the normal motor.

Thus, frequency control permits a reduction of at least 60% in the losses in a 3:1 speed range drive.

Since the power cost is only a small item in the cost of rolling steel, you are no doubt wondering why you should get excited about another 60 Kw or so for the runout table drives. Well, for one thing, when you buy the equipment, you are paying for the extra capacity, in motors, motor-generator sets, control, and additional AC-DC conversion equipment. But factors more important than either power cost or first cost are the avoidance of mill delays and the decrease in maintenance expense. These are intangible benefits, and it is difficult to demonstrate just how they may be obtained. However, the greater the heat loss in a small motor, the greater becomes the possibility of failure, with concomitant delay and maintenance cost.

TORQUE REQUIREMENTS AND HEATING LIMITATIONS

The torque requirements of a runout table or coiler drive are readily determined from the mechanical data of the drive and the time cycle of operation.

In laying out the duty cycle for a table drive, it is well to borrow a tip from the automobile tire makers and remember that while the motors start and stop the rolls, the coefficient of friction starts and stops the metal on the table. The maximum rate at which metal can be accelerated or decelerated by force from the rolls equal "g" times the coefficient of friction. Tests show that this coefficient of friction is of the

Figure 3—Typical characteristics of squirrel cage induction motors operating at one-third frequency and voltage. Power factor scale in per cent torque and current scales is arbitrary.

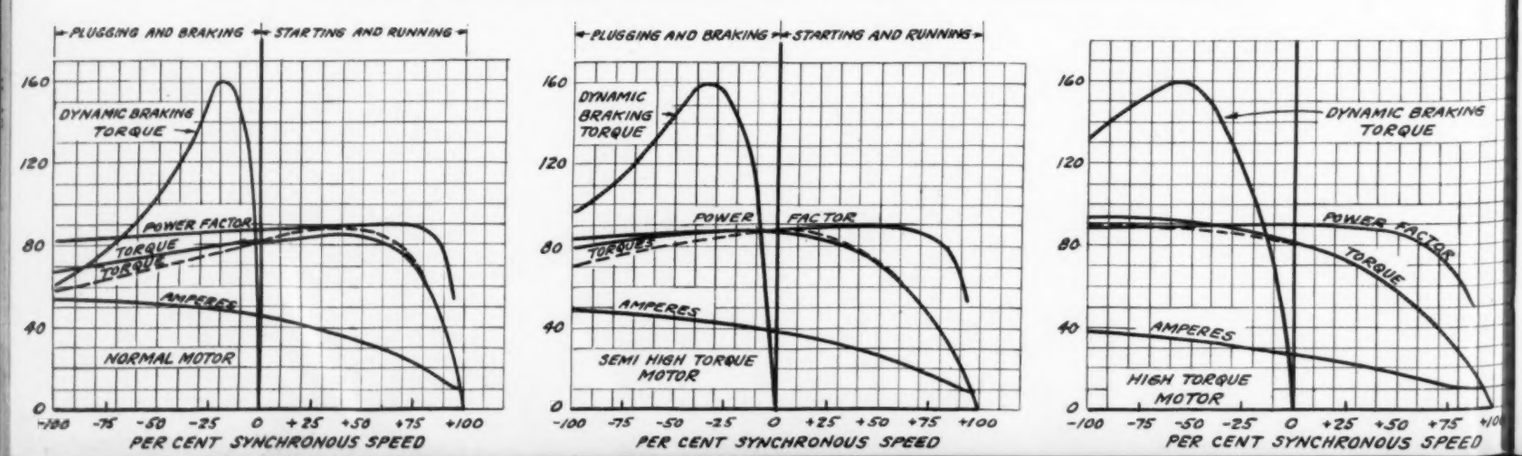


TABLE I

TYPICAL INDUCTION MOTOR ACCELERATING AND DECELERATING LOSSES

Cycle	Method of Operation	Accelerating or Decelerating Losses			
		*Rotor Losses	Stator Losses in Various Motors		
			Normal	Semi-High-Torque	High-Torque
A	Start at full frequency and voltage	9	12	6	3
	Plug from full speed to rest	27	36	18	9
	Total	36	48	24	12
	Total rotor and stator losses		84	60	48
B	Start at full frequency and voltage	9	12	6	3
	Dynamic brake from full speed to rest	9	12	6	3
	Total	18	24	12	6
	Total rotor and stator losses		42	30	24
C	Start at 1/3 frequency and voltage	1	1.3	.7	.3
	Accel. to full speed by frequency control	0	2.7	5.3	8.0
	Decel. to 1/3 " " " "	0	2.7	5.3	8.0
	Plug from 1/3 speed to rest	3	4.0	2.0	1.0
	Total	4	10.7	13.3	17.3
	Total rotor and stator losses		14.7	17.3	21.3
D	Start at 1/3 frequency and voltage	1	1.3	.7	.3
	Accel. to full speed by frequency control	0	2.7	5.3	8.0
	Decel. to 1/3 speed " " "	0	2.7	5.3	8.0
	Dynamic brake from 1/3 speed to rest	1	1.3	.7	.3
	Total	2	8.0	12.0	16.6
	Total rotor and stator losses		10.0	14.0	18.6

*The rotor losses are those occurring in a 100% efficient motor. They are also true losses for full voltage starting, plugging, and dynamic braking. On frequency control, the additional rotor losses incurred because the motors are not 100% efficient, are included in the values of stator losses.

order of 25 or 30%, so that the maximum rate of acceleration or deceleration possible is about 500 feet per minute per second. Any attempt to exceed this rate will merely result in slippage and slower operation, since the coefficient of friction is reduced when slippage occurs. It should also be borne in mind that with any method of acceleration or deceleration, the peak torque produced by the motor is materially above the average value, and thus lower rates must be used if slippage is to be avoided. This applies particularly to dynamic braking, with its extremely pronounced peak torque.

When the WR^2 and friction load of the drive are determined, and the operating duty cycle is established, the motor torque requirements can be obtained by well known means. However, a word of caution is advisable here. There is no fixed ratio between the average torque required, and the starting or maximum torque of the proper motor. This ratio varies with the type of motor, the applied frequency, the voltage regulation of the alternator, and the ratio of friction torque to accelerating torque.

Since the maximum torque of a motor is a function of frame size, the smallest frame which will meet the desired accelerating and decelerating time is fixed when the motor torque requirements are known. Often, however, the heat dissipating capacity of the motor is the limiting factor and a larger frame than that determined by the torque requirements alone will be needed.

The frame size required to limit the motor temperature rise to a safe figure is, of course, a function of the heat loss in the motor, and the motor's ability to dissipate this loss. The heat loss per cycle of operation is, as shown in Table I, a function of the stored energy in the drive and the method of operation. The total heat loss in any period of time is the loss per cycle, times the number of cycles, plus the loss during full speed operation. The heat dissipating capacity of the various motor frames with various types of cooling is known, and thus the frame size required for a safe temperature rise is readily determined.

Now, what can we do to reduce the torque requirements and the heat loss of the motor to obtain a less expensive, more efficient, and better performing drive? First, we can remove excess weight from the rolls, bringing the WR^2 to a minimum. Any reduction in WR^2 is reflected directly in reductions in torque and in losses. Second, we can choose the method of operation which produces the lowest losses consistent with the operating requirements.

SELECTION OF TYPES OF MOTORS AND METHOD OF OPERATION

The type of motor needed for a given application does not depend on the torque requirements, since sufficient torque can be produced by any of the three types. It depends rather on the duty cycle and the method of operation.

Consider, for example, a table to operate under starting-plugging control. For a frequently repeated cycle, the high-torque motor must be used. The additional losses in the other types would involve such an increase in motor size and M-G set capacity that the normal or semi-high torque motors could not be economically applied. If the cycle is repeated less frequently, the accelerating and decelerating losses are reduced, and the running losses increased. The semi-high-torque motor may be applicable, as its more desirable running characteristics may offset its poorer starting and stopping characteristics. If the duty on the table is chiefly continuous running, and starting and stopping are only infrequent, the accelerating and decelerating losses are of only minor importance, and the normal motor should be used.

Now, assume that this table must still operate on a rapid cycle, but that it will be stopped by dynamic braking from top speed, rather than by plugging. The accelerating and decelerating losses will be cut in half, and the semi-high-torque motor may be found applicable. Its starting and stopping performance will be inferior to that of the high-torque motor, but other considerations, such as first cost, improved running performance, and higher horsepower rating at low frequency, may render the semi-high-torque motor desirable.

If the table operates on a rapid cycle, and over a fairly wide speed range, then frequency control should be used. The large reduction in accelerating and decelerating losses made possible by this system of control will greatly reduce their importance as compared with the running losses. For these drives, the normal motor should be used, since it has the best running characteristics of the three types. The normal motor, on account of its low slip, will also "stay in step" with the alternator on acceleration and deceleration better than the other types will. It is immaterial whether final stopping is accomplished by plugging or by dynamic braking, since the decelerating losses become of minor importance. The choice of the method of final stopping should be determined by the operating requirements. For example, reversing features are commonly required on table drives. Here plugging for final stop is recommended, since no additional equipment is required, and the operator can determine the proper time to remove plugging. On coiler drives, reversing features are not often provided, and it is difficult for the operator to see when the coiler has come to rest. Here dynamic braking is recommended, even though it involves an additional generator for furnishing direct current excitation to the motors.

For coiler service, it is desirable to use motors with good speed regulation. Furthermore, the load during coiling when the motors are operating at full speed, is a very important part of the cycle. Thus, the normal motor, with its low slip and high running efficiency should be used.

It is evident that frequency control is the preferable method of operation for all table and coiler drives operating over wide speed ranges, and on frequently repeated cycles of rapid acceleration and deceleration. This method of control will permit the use of the normal squirrel cage motor, which is the least expensive and the most rugged and efficient of the three types. The great reduction in losses made possible by frequency control will, in addition to saving power, permit a reduction in the size and cost of the motors and sets, and provide a higher margin of operating safety in the drive. Frequency control is not new or untried. It has been in service for a number of years on both table and coiler drives. It has proved amply rapid to meet the most severe requirements of acceleration and deceleration, and is benefiting the users in reduced power bills and decreased maintenance. On one strip mill installation of about 500 motors, which has been operating for 4 years under frequency control, it is reported that not one motor has been lost on account of electrical burn-outs.

A bank of adjustable frequency sets supplying runout table motors

MOTOR SPEED AND FREQUENCY

The choice of motor speed and the frequency range of the power supply is made primarily on cost. The final selection is usually a compromise based on three points:

(1) Direct connected motors are desirable, as gears introduce another element of cost and maintenance.

(2) The best overall motor performance is obtained with a 4-pole design, although good performance can be obtained in small induction motors of 10 or even 12 poles.

(3) It is desirable to keep the top frequency as high as possible, to develop the most output per pound from the motors and the adjustable frequency set.

Present practice limits the top frequency to about 60 cycles, but there is no reason why frequencies of 75 cycles or higher should not be used provided that such a high frequency does not increase the cost of the adjustable frequency set. In most cases, the choice of speed and frequency is obvious. For example, a drive with a top speed of 800 RPM would use 8 pole direct connected motors, with a top frequency of 55 cycles. A drive with a top speed of 300 RPM would use 4 pole gear-motors with 6:1 gears, and a top frequency of about 62 cycles. The choice in borderline cases can be properly made only by a detailed cost comparison.

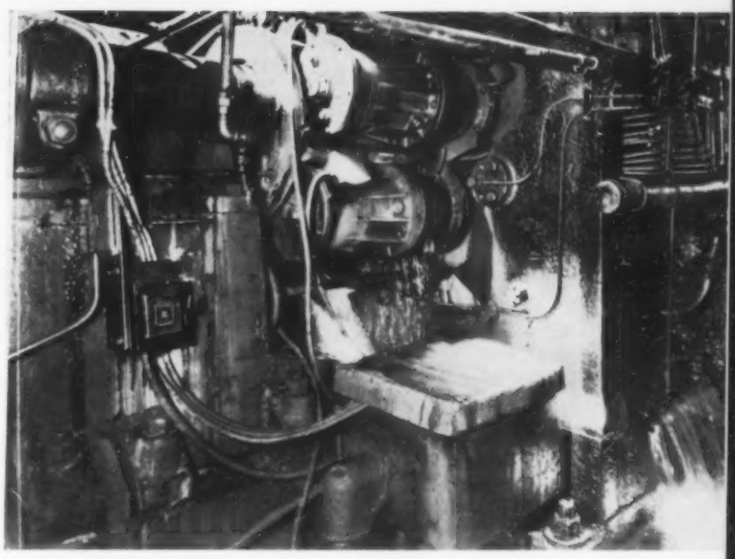
MECHANICAL FEATURES OF MOTOR

Under this heading, we may group method of enclosure, type of insulation, type of bearings, method of mounting, and, for gear-motors, type and arrangement of gears. There is not much to be said regarding the last four points. Cartridge type ball bearings are practically standard for table and coiler motors. Methods of mounting are available to meet all requirements. Gear-motors with reliable built-in gears can be obtained in either concentric or offset shaft designs, and with foot or flange mounted gears, bringing to low speed drives better motor performance and economy of first cost and space than were obtainable a few years ago.

The method of enclosure and the type of insulation used on the motor warrant more consideration. In spite of the fact that probably a majority of the motors now operating on table drives are of the open construction, the authors feel that all such motors should be provided with complete enclosures. It is true that the motors are often protected in a measure by over-hanging portions of the table. However, the atmosphere of a steel mill, laden as it is with soot and oxides, and often with steam and oil vapor, is not conductive to the best life of electrical insulation. Protecting the motors by complete enclosures will pay for itself in reduced maintenance.

The type of enclosure is again a matter of cost. The least expensive enclosed motor is the totally-enclosed non-ventilated type. Next, in order of installed cost, are (1) the totally enclosed fan-cooled motor; (2) a motor similar to the fan-cooled motor, but with the fan removed, and unfiltered air blown through the ventilating passages, and (3) the totally-enclosed forced-ventilated motor, which requires a supply of clean air. The heat dissipating capacity of these four types is in inverse order to the cost. In general, the totally-enclosed motor should be used unless a reduction in motor size sufficient to compensate for the increased cost can be obtained by using a more expensive form of enclosure.

The authors believe that all motors for runout table and coiler service should have Class B insulation. This insulation has a much greater margin of safety above its specified maximum temperature of 115 degs. C. than Class A insulation has above its limit of 95 degs. C. This additional margin of safety is desirable not only to provide for the high ambient temperatures which sometimes occur, but also to take care of unforseen conditions. When a table drive is first laid out, an attempt is made to determine the most severe cycle of operation, and to design the motors accordingly. However, after the drive is installed, we find only too frequently that the rolling schedules have been changed, and thus the drive is operating under more severe conditions than originally contemplated. In such cases, the additional margin provided by Class B insulation may save many shutdowns and much maintenance expense.



Totally enclosed water tight squirrel cage motors driving a hot strip coil

Although Class B insulation increases the cost of a motor by an appreciable figure, the additional cost on the drive is often negligible. The higher permissible temperature rise frequently allows a reduction in motor frame size, or the use of a motor with a less expensive form of enclosure. Incidentally, the authors feel that Class B insulated motors should be designed to operate at or near 75 deg. C. on the operating cycle, and that there is little justification for the practice of calling for 55 deg. C. rise on a Class B insulated machine.

ADJUSTABLE FREQUENCY SETS

The authors know of no simple rule for selecting the size of an adjustable frequency set which will insure adequacy without extravagance. However, the two requirements of the complete drive, namely, the ability to develop sufficient torque, and the capacity to handle the energy requirements, apply equally to the roll motors and to the sets supplying them.

Let us first consider the alternator from a heating standpoint. As a rough approximation, the *minimum* Kva rating must equal the total full load input to the table motors. This is based on the assumption that on the duty cycle the motors operate at or near rated temperature rise. If this minimum size of alternator can also be made to maintain satisfactory voltage on acceleration and deceleration, it is adequate.

The maintenance of voltage during starting and

stopping is accomplished very simply by applying overexcitation to the alternator field. The field is connected across the 230 volt supply in series with a resistor, and is wound to develop normal excitation at a voltage considerably below 230 volts. During starting and stopping, the resistor is automatically short-circuited. The effectiveness of this expedient is evident from Figure 4.

Figure 4 shows the volt-ampere characteristics of a runout table alternator at normal field, and with three different degrees of field forcing. Depending on the amount of forcing, the alternator will maintain 90% voltage on rated power factor starting peaks of 250, 300, or 400% of its normal rating. In general, a starting voltage of 90% will permit the table motors to develop an average torque equal to or slightly higher than the full voltage value, since the voltage rises during acceleration due to the decrease in motor current and the improvement in motor power factor.

The rated power factor of an alternator is a measure of its flux capacity, and the lower the power factor, the larger and more expensive the machine becomes. With proper forcing, sufficient flux capacity can usually be obtained in a 70% PF machine, and it is a waste of money to use machines of lower power factor.

The D.C. driving motor must have sufficient overload capacity to carry the accelerating and decelerating peaks without distress. In general, the rating of the D.C. motor is determined entirely by the peak loads during starting and stopping, and not by heating requirements. The motors commonly used on adjustable frequency sets are good for repeated peak loads of 200% at basic speed, and 150% at four times basic speed. Motors of higher overload capacity are available at increased cost, but are not usually necessary.

It is desirable to rate both motor and alternator of the set on a 40 deg. C. basis, since these sets are often located at points where ventilation is restricted.

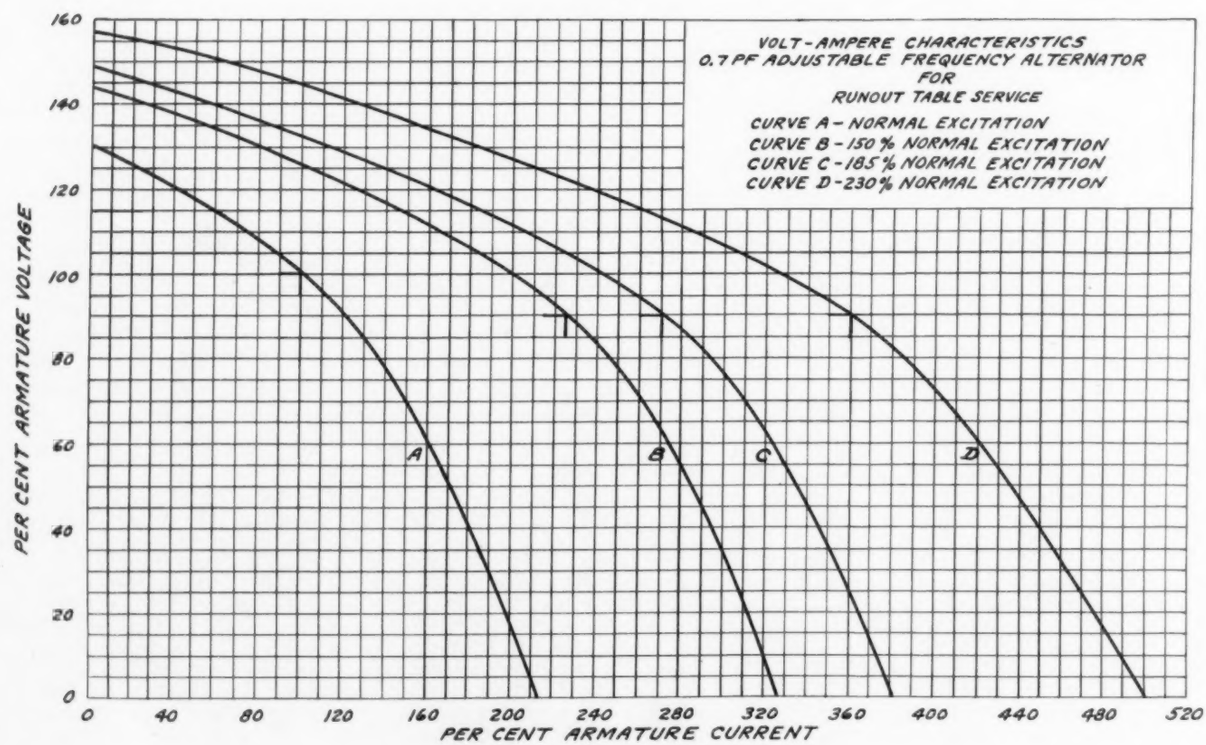
For frequency control, low WR^2 is desirable, to keep the torque requirements of the driving motor to a minimum, and the motor of the set should have "fast fields" to give quick response when speed changes are desired.

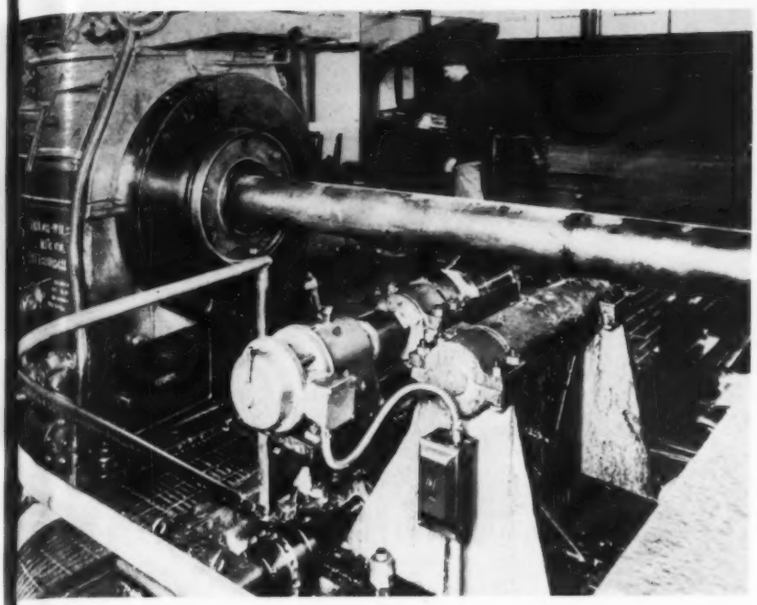
The selection of the proper M-G set becomes primarily the choice of an alternator to meet the heating requirements, and a motor to carry the peak loads. Both these factors will vary widely with the method used for accelerating and decelerating the rolls. With starting-plugging control, the set must handle both accelerating and decelerating losses, and thus must be of large capacity. With starting-dynamic braking control, the set is relieved of the decelerating losses, and its continuous capacity may be reduced. With frequency control, a still smaller set may often be used. In every case, the actual rating should be determined from a full consideration of the inputs to the roll motors.

CONTROL EQUIPMENT

Once the operating cycle, the method of operation, and the ratings of the machines have been determined, the requirements of the control equipment have been pretty well established. Of course, in laying out the control, mill practice should in general be followed, and control devices of proven ability to stand up under severe operation should be used. There are, however,

Fig. 4





Gearmotor driving roll of pipe threading machine table

certain special features which should be provided, as follows:

1. The magnetic starter for the motor of the adjustable frequency set should be arranged to apply excitation to the alternator when the set starts, and to remove it when the set stops. Unlike the DC motor, the alternator cannot remain excited at standstill without dangerous overheating of its field.

2. The alternator field forcing contactor should be arranged to apply forcing automatically whenever the drive is started or stopped, and this forcing should be removed automatically after a time sufficient to permit the motors to reach full speed, or to decelerate to rest. If dynamic braking is used, the direct current excitation to the table motors should be applied automatically when the stopping indication is given, and should be removed by definite time control.

3. If frequency control is used, it is desirable to provide definite time control of both field strengthening and field weakening on the direct current motor, and to have the rate of strengthening and weakening independently adjustable.

4. With frequency control, if very rapid deceleration is required, it is advisable to connect an AC dynamic braking resistor across the alternator terminals during deceleration. Some of the stored energy in the table drive will be dissipated in this resistor, and the adjustable frequency set will be relieved of part of the peak load.

5. Sufficient instrument equipment should be furnished to facilitate initial adjustment and subsequent servicing of the control set. This usually means a voltmeter, an ammeter, and a field ammeter for the alternator. On coiler drives, an ammeter should be provided for the driving motor of the set, as this gives a means of observing the actual coiling load, and enables the operator to know whether or not the speed setting is correct. An ammeter for the direct current motor is also desirable on all drives operating under frequency control, to assist in determining the proper time setting of the field weakening and field strengthening relays.

6. Tachometers should be provided on all adjustable frequency sets, so that the speed at which the table or coiler is operating may be observed.

7. Proper overload protection should be provided. Instantaneous overload relays are desirable for the motor of the adjustable frequency set, since they permit the motor to carry heavy loads up to the commutating limit at any time. A thermal overload relay on the alternator, arranged to trip out the driving motor, will provide protection against unsafe temperature caused by long continued overload.

Individual overload protection for table and coiler roll motors is extremely desirable, since these motors are often stalled by accumulation of scale between the rolls and the aprons, and since occasionally a bad connection in the wiring may cause single phase operation. To provide this protection, double pole series type thermal relays actuated by motor current are recommended. The series relay is responsive to a temperature closely approximating the internal temperature of the motor winding, and provides excellent single phase protection.

A triple pole hand-operated disconnecting switch is desirable for each table motor, to permit the roll to operate as an idler in case of motor failure, until repairs can conveniently be made. The overload relay may be combined with this switch, to provide means for opening all three motor lines in case of overload. Compact and rugged devices are available for this service, and may be furnished with water-tight or splash-proof cases which serve as junction boxes for connecting the individual motors to the bus along the table.

It is undesirable to trip the coiler motors off the line in case of overload, since such action might result in a cobble in the coiler. Furthermore, it is unnecessary to provide means for individually disconnecting the motors. For coiler drives, thermal overload relays should be provided for each motor, and they should be arranged to operate a bell or an annunciator, or both, to call the operator's attention to the motor in difficulty.

In this paper, the authors have endeavored to discuss the underlying principles governing the application of electric drives to tables and coilers, rather than to describe the selection of an equipment for an actual installation. The manufacturer of the electrical equipment should be made responsible for the final selection of the apparatus, but a knowledge of the fundamentals upon which this selection is based should render it easier for the Purchaser to check the manufacturers' recommendations against his operating requirements.

SELECTION OF LUBRICANTS
FOR COLD ROLLING OF STRIP STEEL

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▲ THE LUBRICANTS discussed in this paper are those used in connection with the rolling of steel strip through finishing mills, during the final stages of processing. The term by which these lubricants are more commonly known is "Roll Oil", of which there are a number of types to meet various applications.

The primary purposes of a roll oil are (1) to minimize friction between the strip passing through the mill, and the work rolls of the mill, and (2) to furnish a protective coating on the strip to prevent scratching when two surfaces of the metal are in contact, and (3) to resist atmospheric or other conditions to which the finished strip may be subjected prior to further processing.

The roll oils might be classed under three main headings, (1) Vegetable oils; (2) Mineral oils; and (3) Compounded oils. One of the oldest known vegetable oils is Palm Oil, which has been used extensively in the rolling of sheet and tin plate, and is usually applied by a dauber or by dripping on the upper side of the strip, and by means of a wiper or roller to the lower side as it enters the first or second stand of a tandem mill, or before entering the work rolls on a reversing mill. Occasionally the oil is sprayed onto the strip to help spread the film more uniformly and to clean the surface of the strip. Other oils of this type have been used with more or less success.

From our observations, we find the use of straight mineral oils increasing and, in many cases, replacing the vegetable oils, especially where the mill speeds have been increased, and greater cooling ability is required. The mineral oils used are of different viscosities, the more common being within a range of from 100 seconds at 100°F to 200 seconds at 100°F, depending on the application.

The use of compounded oils is of great interest at this time for the reason that certain changes are continually being made in rolling practice and mill conditions, and experience has taught us that by blending various materials with mineral oil, a resulting product will be formed which will often have a decided advantage over the use of straight vegetable or mineral oils for cold rolling steel.

Certain animal and vegetable oils have characteristics which are desirable for many applications. They are usually very adhesive, and tend to spread readily when applied to steel strip. On the other hand, these oils have fairly high carbon residue values and have a tendency to leave carbon deposits on the finished steel strip when it is annealed. Also, oils of this type as a rule are not very good coolants, are rather costly, and very often tend towards rancidity.

Mineral oils have radically different characteristics than the animal and vegetable oils in that they are not as adhesive on steel strip, and do not spread quite as readily, yet they do possess many desirable qualities. They are excellent coolants, have low carbon residue values, are less costly, and are an extremely stable form of hydro-carbon.

From the above it can be readily seen that the ideal roll oil would be a combination of the characteristics of mineral oil, and the animal and vegetable oils. This blending of oils can be accomplished very satisfactorily by careful selection of the mineral oil and the compound used. Among the more common compounds we find beef tallow, degras, lard oil, palm oil, castor oil, cottonseed oil, peanut oil, and others; all of which form fairly stable products when blended with the proper mineral oil.

It is also a known fact that by the proper compounding of a mineral oil, the resulting product is one which has high film strength, which is a characteristic desired for many applications. The film strength of the compounded oils is usually in direct proportion to the type and percentage of compound used.

Recent research developments have afforded a new means of compounding oils which have heretofore been impractical. This refers to the use of sulphur, chlorine, etc., in the compounds, and which have shown outstanding results.

In recent years the speeds of finishing mills have been continually increased, and the problem of roll expansion from the heat generated has called for some method of dissipating this heat. The answer to this problem has been the use of soluble oil emulsions as a roll oil, and a cooling medium for the rolls. The emulsions formed with soluble oil and water, when used for this dual purpose, usually call for a good circulation system equipped with temperature control of the emulsion, and proper cleaning and filtering facilities.

Soluble oils in reality would come under the classification of compounded oils, and yet are in a class of their own. There are many kinds of soluble oils made up of various mineral oils, having different viscosities,

and the emulsifying agents used also vary in form. This is due partly to the varying water conditions which must be met in forming an emulsion in which the oil will not separate from the water, even if allowed to stand idle for long periods of time.

The use of soluble oil emulsions has proven extremely satisfactory when properly applied, and where the correct type of oil has been selected. With particular attention to the use of these emulsions as the roll oil, it should be noted that the correct ratio of the amount of soluble oil and water is very important from the standpoint of minimizing friction between the strip and the work rolls, and in furnishing the desired protective coating on the steel after it has been rolled.

It might be interpreted from the discussion on soluble oil emulsions that a circulation system is required in all cases. We most heartily endorse the use of circulation systems wherever practical, yet there are many finishing mills using soluble oil emulsions with satisfactory results which are not so equipped.

When using soluble oil emulsions we recommend that the users make frequent checks on the proportion of mixture, since water has a fairly high rate of evaporation under certain conditions, and the ratio of water and soluble oil in the emulsion should be kept as uniform as possible to obtain maximum results.

One of the more recent developments has been the introduction of a soluble wax, and although its use has been somewhat experimental, it has shown some very promising results where it has been desired to lithograph, enamel, or otherwise coat the finished steel.

So far the subject has been dealt with in a rather general manner and we have briefly outlined the types of oils and their uses. We have not as yet formulated any definite rules for the selection of a roll oil because our experience has shown us that no two operations are alike, and many factors enter into the selection of the proper roll oil. In selecting a roll oil, there are certain characteristics which should be considered and which of course vary with each particular operation; but the basic points might be listed as follows:

1—Film Strength
2—Thermal Properties
3—Ease of Application
4—Ease of Cleaning
5—Carbon Deposits
6—Slushing Characteristics
7—Adhesiveness
8—Ability to Spread
9—Economy.

There are other factors which enter into the selection of the roll oil. However, the above nine points

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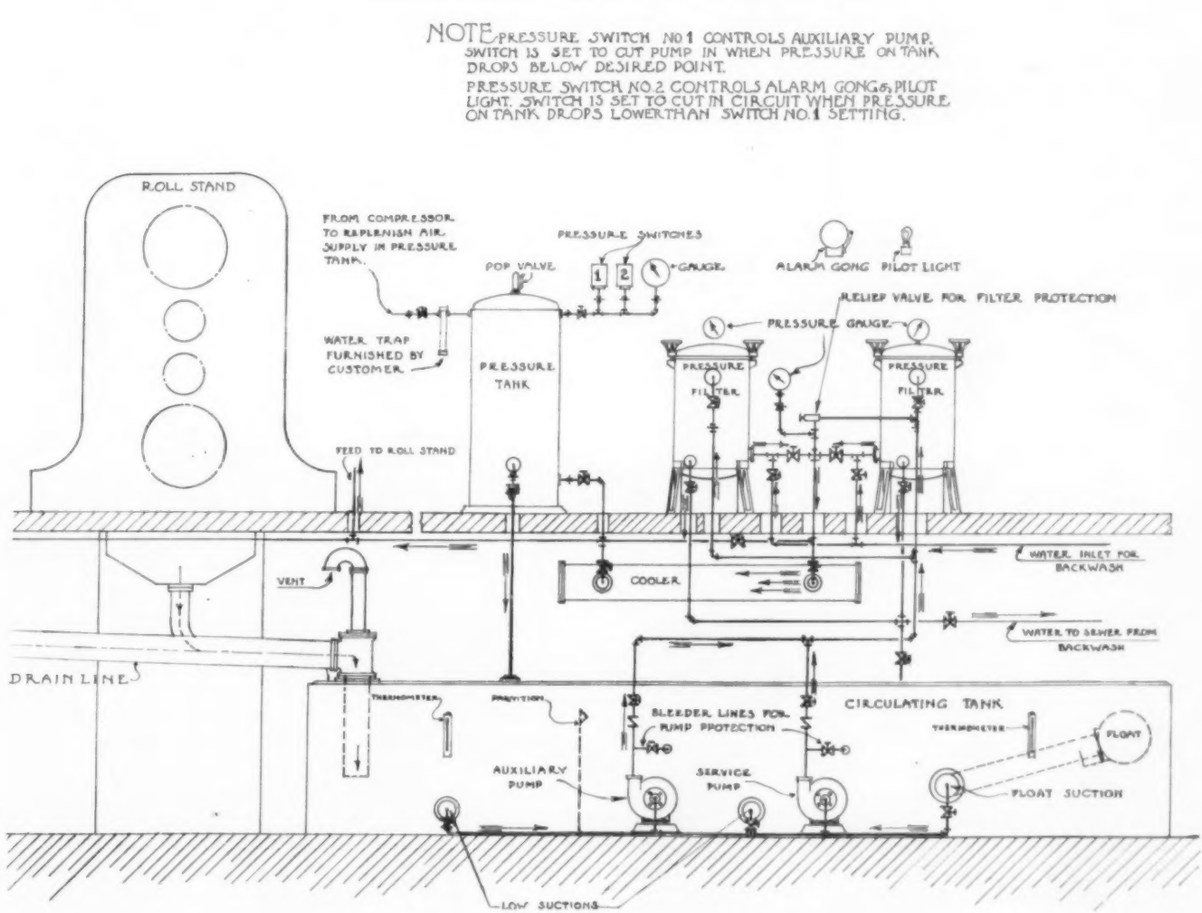
Circulation system used with soluble oil emulsions.


NOTE-PRESSURE SWITCH NO 1 CONTROLS AUXILIARY PUMP. SWITCH IS SET TO CUT PUMP IN WHEN PRESSURE ON TANK DROPS BELOW DESIRED POINT.
PRESSURE SWITCH NO 2 CONTROLS ALARM GONG & PILOT LIGHT. SWITCH IS SET TO CUT IN CIRCUIT WHEN PRESSURE ON TANK DROPS LOWER THAN SWITCH NO 1 SETTING.
ROLL STAND
FROM COMPRESSOR TO REPLENISH AIR SUPPLY IN PRESSURE TANK.
PRESSURE SWITCHES
POP VALVE
GAUGE
ALARM GONG
PILOT LIGHT
RELIEF VALVE FOR FILTER PROTECTION
PRESSURE GAUGE
WATER TRAP FURNISHED BY CUSTOMER
PRESSURE TANK
PRESSURE FILTER
FEED TO ROLL STAND
VENT
COOLER
WATER INLET FOR BACKWASH
WATER TO SEWER FROM BACKWASH
DRAIN LINE
THERMOMETER
CIRCULATING TANK
BLEEDER LINES FOR PUMP PROTECTION
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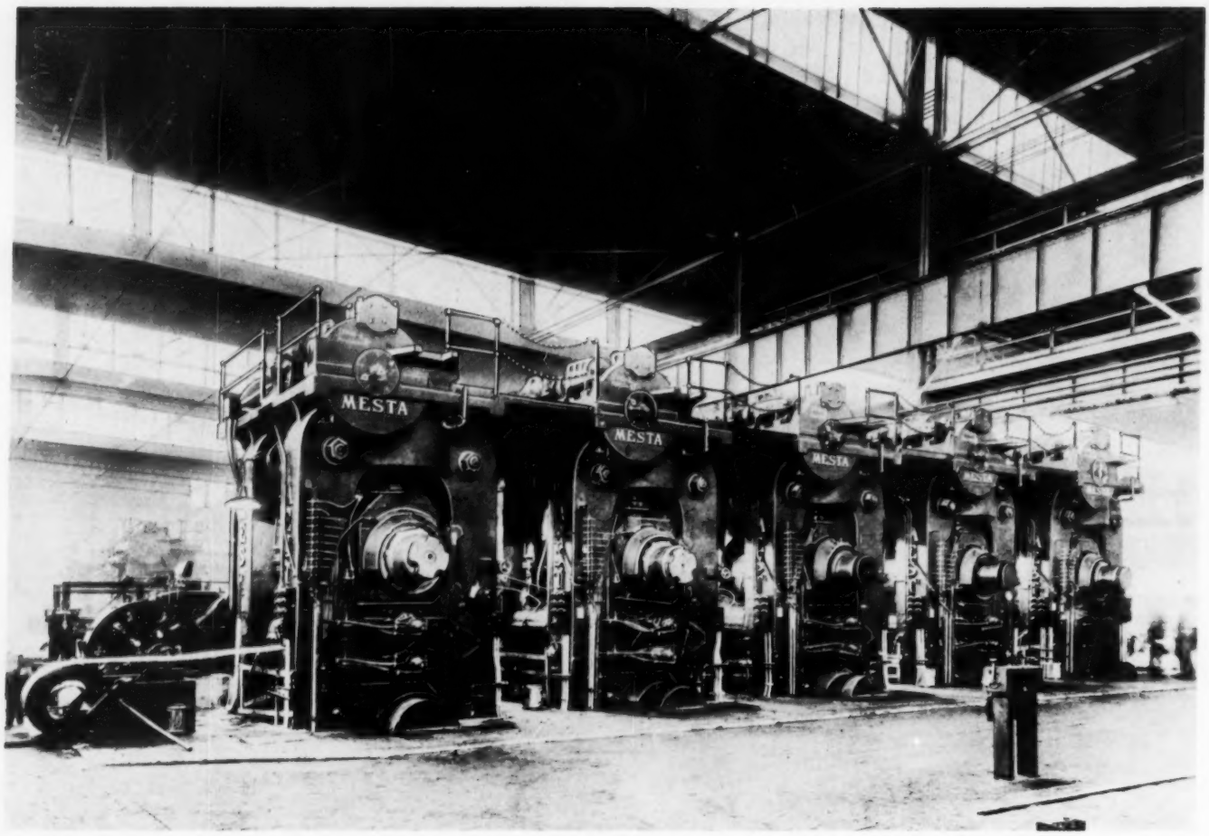
AUXILIARY PUMP
SERVICE PUMP
FLOAT SUCTION
LOW SUCTIONS



Typical tandem mill

are usually the basis for consideration. Let us briefly discuss these various points.

1—Film strength. It has been our observation that the slower the operation, the greater the film strength required, because greater pressures are exerted for longer periods of time, on the sections of the steel passing through the rolls. The film strength of a mineral oil may be increased by the addition of a properly selected compound.

2—Thermal properties. Usually on the slow speed mills the amount of heat generated is not great. In the case of high speed mills, the oil or emulsion used must have relatively high heat conductivity and high specific heat, and where this is the case, usually film strength is not so important a factor, whereas in the case of slow speed mills the film strength is a more important factor than the cooling ability.

3—Ease of application. Temperature conditions and methods of handling often affect the type of oil which is used. The increased use of lighter oils and soluble oils has greatly lessened this problem. Too viscous an oil oftentimes is hard to apply because of its sluggishness in spreading. Soluble oil emulsions have become extremely popular because of the ease in applying and because of the uniform body under varying temperatures.

4—Ease of cleaning. This point has been one of much consideration due to the fact that strip after finishing may be used in different manufacturing processes. In some cases where the metal is lithographed, enameled, or otherwise finished, the coating which is left on must either be cleaned off easily or be non-effective in the processing which is used. Different methods of cleaning are employed and the roll oil wherever possible should be adapted to the standard cleaning practice unless some radical improvement can be shown in rolling operation to justify a change in the cleaning method.

5—Possibility of carbon deposits during annealing. Much time might be devoted to the discussion of this subject due to the fact that there are several types of annealing furnaces, different conditions in creating reducing atmospheres, etc., which enter into the picture. It should be the primary thought in roll oil selection to obtain one which has a relatively low carbon residue value because during annealing any roll oil which is left on the finished product will go through a process of destructive distillation, and occasionally leaves a deposit on the surface of the metal which may be objectionable, and may result in costly hand cleaning operations.

6—Slushing characteristics. This particular point is important when the finished strip is subjected to various atmospheric conditions for any length of time before it is further processed. Certain types of roll oils will protect the finish of the metal against oxida-

tion or other reactions for a greater length of time than others. Therefore the general atmospheric conditions in which the finished strip is kept should be carefully considered.

7—Adhesiveness. This point, with reference to a roll oil, is one in which a balanced condition must be met, thus the oil must have a certain amount of ability to cling to the finished strip and yet, on the other hand, must not leave a gummy deposit on the strip which will tend to pick up dust and foreign matter from the surrounding atmosphere or from other sources which might be left on the strip when it is annealed. This balanced condition is usually obtained by proper blending of animal or vegetable fats with a mineral oil, or in the case of soluble oils by the blending of a proper mineral oil with the correct type of emulsifying agent, and in some cases the introduction of a rust inhibitor when required.

8—Ability to spread. This of course is a factor to be considered, in connection with the method of application, width of strip necessary to cover, etc. In the case of wider strip it is frequently necessary to apply the oil at several points in order to allow it to spread fairly uniformly over the surface of the metal before entering the work rolls. When the oil does not spread properly over the surface of the metal it necessitates the work rolls forcing the oil to spread in addition to the rolling operation, and may even cause wavy spots on the finished metal and excessive heating at spots on the rolls.

9—Economy. Economy is a vital factor in any steel mill operation. This in a roll oil should, however, be considered further than its first cost. It is a known fact that with the proper roll oil the power required to drive the mill may be affected to a great extent. Also, the value of the protective coating which the strip carries after rolling shows up in figuring profit or loss. The cost of cleaning is another factor which should be considered. There are other factors which enter into the economic selection of a roll oil which vary with operating practices and conditions.

So far we have dealt mainly with the roll oils themselves and their use in connection with the more modern mills. There are two main types of modern mills, first, the tandem mills, which usually consist of two or more finishing stands through which the strip passes in one direction in a continuous finishing process. In the case of the tandem mill, sometimes the roll oil is applied before entering the first stand, or where a number of stands are used and the first acts as a surface leveling pass the roll oil is applied after the first stand. In rolling tin plate, the roll oil is usually applied before entering the first stand. With this type of mill, the work rolls are driven, the strip is fed in a free manner to the first stand and coiled onto a tension reel from the last stand.

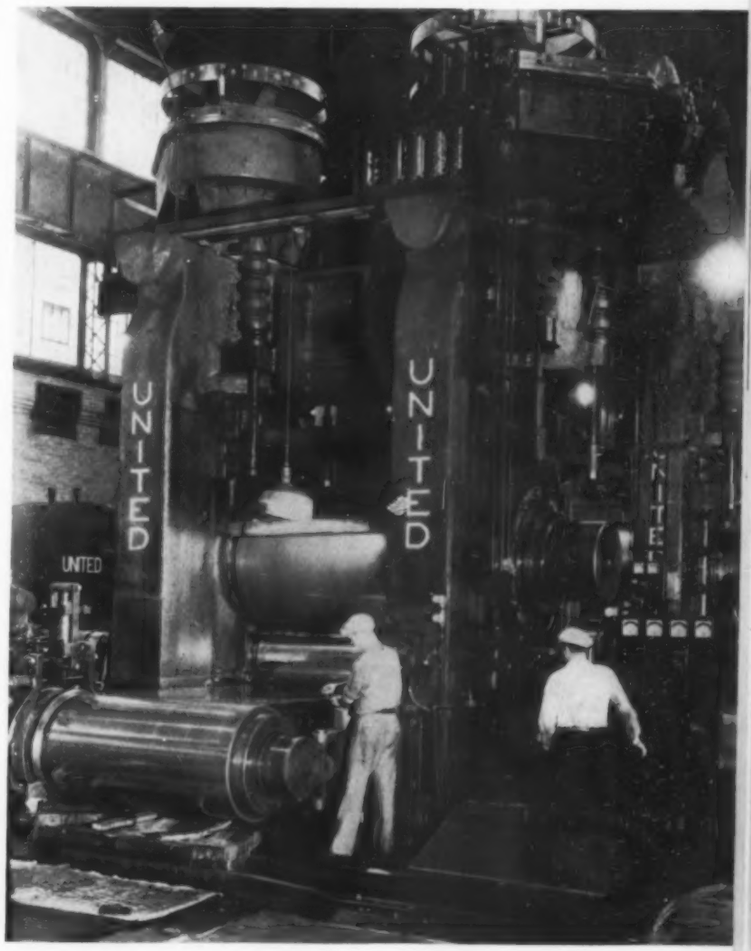
The second class of mills covers that type which has a single four high stand with a tension reel on either end, and the strip is drawn through the mill from one reel to the other, and then reversed, and so on until the desired gage is obtained. On some of these mills the tension reel draws the strip through the work rolls, and on other mills of this type the work rolls are driven, so as to divide up the work between the tension reel and the work rolls.

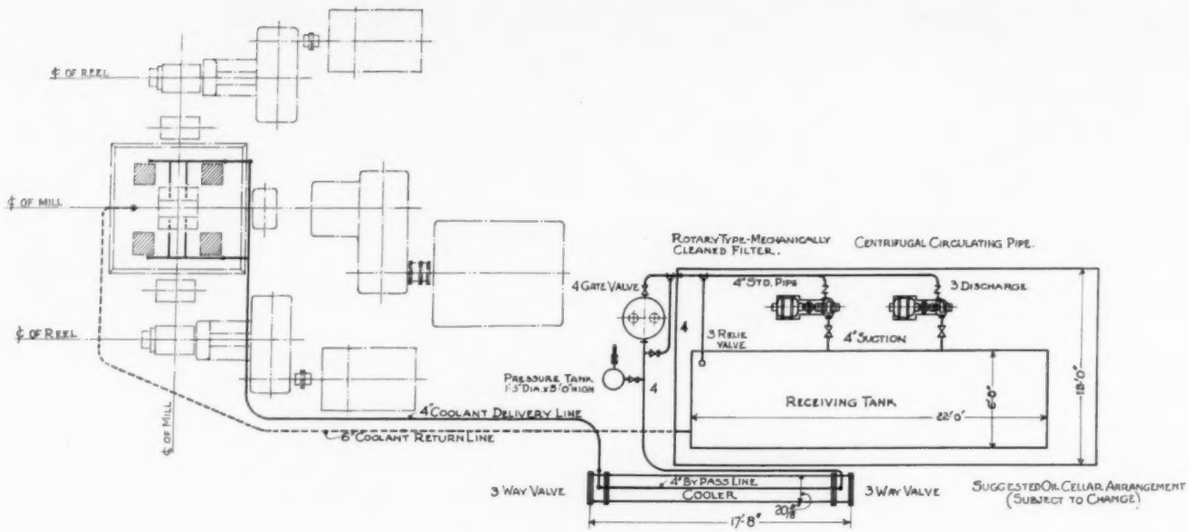
The strip is often put through a skin pass after annealing, and the roll oil requirements are mainly slushing. Sometimes the oil is applied before the strip enters the mill, and in other cases the strip is rolled dry and then slushed. The type of oil used is governed by the use to which the steel is to be put.

As to the steel, we find that almost every conceivable specification is being met by the products being rolled. These steels vary from the softer low carbon steels to the high carbon and alloy steels in various widths and gages.

Referring again to the annealing, our company has spent a great deal of time and study on the various stains which appear on finished strip after rolling. Our research has convinced us that there are three definite types or forms of stains which can be detected on finished strip. The first, with which we are all fairly well acquainted, is the coloring stain, which Metallurgists refer to frequently as a tempering stain, and which seems to be generally agreed is a slight oxide formation which appears at the edge of the strip. Another type of stain which is easily recognized is the carbon forma-

Finished strip coming from a tandem mill.





Circulation system used with soluble oil emulsions.

tion which appears on strip, sometimes in streaks and again in spots. The third kind of stain is in appearance like a gray oxide formation, and oftentimes shows up in spots in different positions on the strip.

In trying to determine the relation between a roll oil and the stains which appear, we have come to the following conclusions, which may be a subject for discussion. We believe that the first type of stain, namely, the so-called tempering stain, can in no way be controlled by the roll oil.

In the case of the second type of stain, or the carbon deposit, we believe that in many cases this can be greatly eliminated by the proper selection of the roll oil, although we would say that the reducing atmosphere very often has a great deal to do with this type of stain; and in some cases we find the roll oil and reducing atmosphere may combine to cause such types of carbon deposit.

In regard to the last type of staining, or the apparent oxide formation which occasionally shows up on strip, it has been our observation that in many cases this formation is caused by foreign matter adhering to the surface and being carried on the strip into the annealing furnace, and when the roll oil is destructively distilled off the strip, the various foreign matters have been known to fuse or crystallize onto the surface of the finished strip. We find this particular type of stain to vary in form and appearance in different operating plants, and which might be traced to either dust or dirt conditions or some practice of handling.

We have noted in several instances that the creeping of the lubricant used on the roll neck of the mill onto the surface of the roll, even in the minutest quantities, will often give staining spots on the finished strip.

In conclusion, the selection of the roll oil should be made only after studying the general rolling practice, cleaning methods, mill speeds, type of mill, type of steel, draughts taken, method of handling, use of steel after finishing, atmospheric conditions, etc., in addition to the characteristics of the roll oil itself, and any other conditions which might affect the resulting product.

We believe the points brought out in this discussion are worthy of the consideration of the men of the Iron and Steel industry. It should be remembered that while no oil could be said to be perfect in every way, yet certain oils will give better results than others. If you as an individual are responsible in any way for a cold rolling operation, we suggest that you will find a study of your present roll oil and its potential possibilities a most interesting and profitable investigation.

ROLL TABLE EQUIPMENT
FOR MODERN WIDE STRIP MILLS

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Paper presented before the A. I. & S. E. E. Convention, Pittsburgh, Pennsylvania. September 24, 25, 26, 1935

▲ THE MODERN wide strip mill is usually designed to produce coiled strip, sheets and plates. Each product requires different handling upon leaving the last stand of the mill and these operations must be performed efficiently and rapidly so that the output will not be restricted by the handling equipment. This equipment consists of pilers, coilers, shears, levellers, trimmers, etc. along with the necessary roll tables to convey the steel from one unit to the other.

To provide sufficient handling room several hundred feet of roll tables are required. On these tables, the use of bevel gearing has been eliminated and individual motors of the squirrel cage induction type are used to drive each roll either direct connected or through suitable gearing. On a mill now being installed approximately 900 motors will be used representing a connected load of 2600 HP. On the mills in this country placed in service during the past year or those which will be installed during the coming year, approximately 3500 motors will be required representing a connected load of more than 9,000 HP. It is evident that the roll tables are large items and very important ones. They are being given careful consideration by the steel producer, mill builder and the electrical equipment manufacturer.

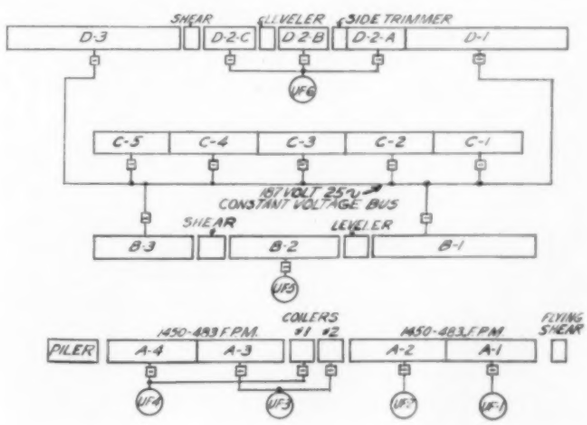
On the earlier installation of individual roll tables, the motors were driving small rolls, running continuously at constant speed and the motors were rated 1 HP. or less. The present wide strip mill not only requires a long heavy roll, but also requires that at least part of the motors be capable of rapid acceleration and deceleration. Naturally the size of the motors has been greatly increased and a mill now under construction will have some rolls that will be driven by 10 HP. motors. The motors are supplemented by suitable control equipment and, when adjustable speed tables are required, by motor generator sets consisting of an A.C. synchronous generator driven by a D.C. adjustable speed motor.

A typical roll table layout is shown in Figure No. 1. The last stand of the strip mill is followed by a flying shear which is used to crop the front and rear end of strip which will be coiled, or cut to length sheets which will be piled. Tables A-1 and A-2 are between the flying shear and the coilers and are from 300 to 350 feet long. Tables A-3 and A-4 run from the coiler to the piler and are approximately the same length as Tables A-1 and A-2. Both tables have the same speed range, the top speed of the table usually being slightly higher than the maximum delivery speed of the mill which will range from 1400 to 2000 FPM. The speed range of a given table is usually 3 to 1. The rolls run at approximately 600 RPM. maximum, so that direct connected motors are practical but quite often the fact that a transfer table is placed alongside the roll table dictates space limitations which make gearmotors a better solution.

When coiling strip, only Tables A-1 and A-2 are used and the table runs continuously except for some acceleration and deceleration during the coiling operation. The entire A table is used when piling and theoretically runs continuously although there is some starting and stopping of the tables especially until the crew becomes skilled in the piling operation.

When rolling plates or heavy gauge sheets, the plate is delivered onto Tables A-1 and A-2 and the tables are stopped. Then the plate is transferred to Table B-1 and Tables A-1 and A-2 again accelerated to the mill delivery speed. This cycle of operation must be repeated two or three times per minute with a rapid rate of acceleration and deceleration. It is this condition of operation which determines the size of the motors driving this table. The motors will have ratings varying from 5 HP. to 10 HP, per roller and the motors used on Tables A-3 and A-4 usually have ratings varying from 1½ HP. to 3 HP. per roller depend-

Figure 1—Schematic layout of roll tables—wide strip mill.



ing upon the amount and rate of acceleration and deceleration desired on the table.

While the speed of Table A is determined by the delivery speed of the mill, the speed of Table B is usually determined by the speed at which it is practical to run the material through the leveller and other processing equipment used in connection with the table. The maximum speed will vary from 300 to 600 FPM. and since the operation on this table can be nearly continuous, it will handle all the material delivered from the mill intermittently at higher speeds. Since the rolls run at approximately 200 RPM., gearing is used between the roll and the motor, either in the form of a gearmotor or with gearing built into the table with one motor driving two rollers.

Figure 2—Installation view of roll tables and coilers—Youngstown Sheet and Tube Company

An installation view of a Mesta mill at the Campbell Works of the Youngstown Sheet & Tube Company showing Tables A-1, A-2 and A-3 and Tables B-1 and B-2 is shown in Figure No. 2. The table on the left-hand side in the foreground is Table A-3 with the coilers located just beyond the bridge. Tables A-1 and A-2 can be seen between the coilers and the mill delivery stand. The table to the right is Table B-2 with B-1 beyond the bridge. In the construction of this table, two rolls are driven by a single motor through suitable gearing, the motor being arranged for flange mounting on the roll table gear case and with the pinion mounted directly on the motor shaft. Tables A-3 and B-2 are identical in mechanical design. The motors are also of the same frame size and mechanical design, the difference in speed of the two tables being obtained by the number of poles in the motor winding and in the different range of frequency applied. Table A-3 has a top speed of 1450 FPM. with the motors running at 1750 RPM. Table B-2 has a top speed of 600 FPM. with the motors running at 720 RPM.

Figure No. 3 shows a close-up view of a section of Table A-1 just in front of the flying shear, illustrating a different table design with a gearmotor mounted inverted and connected to the roll through a flexible coupling. The same housing that supports the roll, supports the gearmotor making a complete roll assembly which can be removed as a unit. The gearmotor itself is shown in Figure No. 4. This table operates in connection with a transfer and must start and stop frequently. Therefore each roller has a 7½ HP. driving motor and each motor is provided with forced ventilation to secure adequate capacity to meet the severe duty cycle. The forced ventilation also provides additional protection for the high ambient temperature and from the heat that can be conducted to the motor through the gear case which is mounted directly on the roll table frame over which hot steel can be transferred.

The roll table equipment as shown in Figure No. 2 represents the extent of this type of equipment for most of the hot strip mills, although one installation now being made has two additional Tables C and D as shown in Figure No. 1. This particular mill is laid out for rolling a large amount of heavy gauge sheet and plate and the Tables C and D will be used for that product only. Table C will run at constant speed of 250 FPM. as will sections D-1 and D-3. Table D-2 will be supplied with variable frequency power for adjustable speeds of 200 to 600 FPM. having the same speed range as the leveller, trimmer and shear with which it will operate. However, all motors on Tables C and D will be mechanically and electrically duplicate, the motors on Tables C, D-1 and D-3 receiving their power at 187 volts, 25 cycle running at 250 FPM. and Table D-2 receiving power from a variable frequency generator at 440 volt, 60 cycles down to 147 volts 20 cycles giving a speed range of 600 to 200 FPM.

To supply the variable frequency power required to run the motors at different speeds, a motor generator set consisting of an A.C. synchronous generator driven by a D.C. adjustable speed motor is used. On installations such as described, two motor generator sets are used for Tables A-1 and A-2 and two sets used for Tables A-3 and A-4. Since Tables A-3 and A-4 are not used when coiling, the control equipment is usually arranged to transfer the sets to either Tables A-3 or A-4 or to the coilers. In practically every case the rating of the set is determined by the requirements of Tables A-3 and A-4 rather than the coilers. The sets usually have ratings ranging from 500 to 750 KVA. at maximum speed and the D.C. driving motor designed for a 3 to 1 speed range to give 20 to 60 cycles.

The general scheme of operation of the variable frequency equipment is as follows. The variable frequency motor generator set is started from a control switch located either on the operator's control desk or in the motor room. Moving the master switch at the control desk to the first point forward or reverse connects all of the motors receiving power from a given M.G. set to the generator and accelerates them to a speed corresponding to the full field speed of the motor generator set. Moving the master switch to the second point weakens the driving motor field, accelerating the motor generator set and the table motors to the

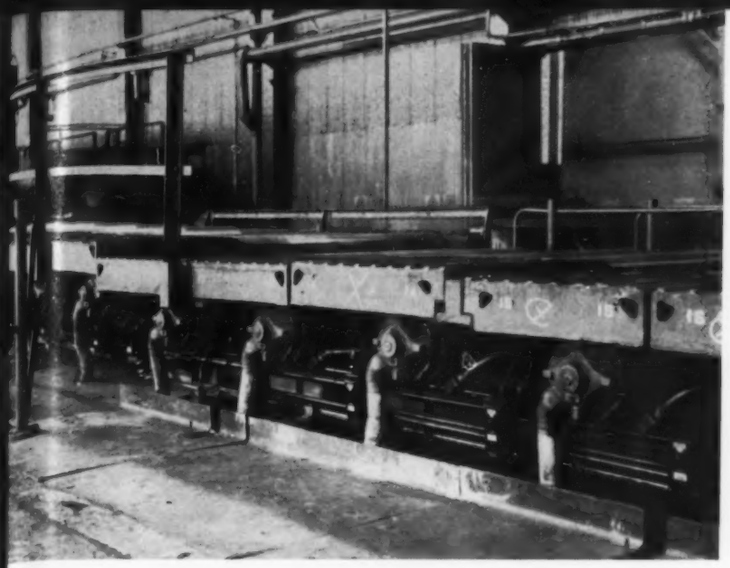


Fig. 3—View of roll table between the mill and coilers. Gearmotor drive

speed corresponding to the setting of the motor field rheostat. Centering the master switch first decelerates the motors by decelerating the motor generator set to its full field speed and then applying D.C. dynamic braking to the individual motors to produce a quick stop. If the master switch is left in the center position for a sufficiently long time to bring the motors to a stop the D.C. dynamic braking is automatically removed by means of a time delay relay. If the master switch is only momentarily brought to the center position and then moved back to the first position. the dynamic braking is immediately removed and the A.C. power applied to the motors.

If the master switch is moved from the second point in one direction to the second point in the other direction, the motors and motor generator sets are first decelerated to base speed and then the motors plugged at low speed and when the motors have come to the base speed in the reverse direction, the M.G. set is automatically reaccelerated to the speeds determined by the setting of the motor operated rheostat.

You will note that in this scheme of operation all acceleration and deceleration between 60 cycles and 20 cycles is obtained by changing the speed of the motor generator set itself. Dynamic braking is applied only after a speed has been reduced to 20 cycles or if the motors are plugged they are plugged only at 20 cycles. The scheme of operation described not only gives the operator a flexible and satisfactory operating table, but permits the use of the minimum size of motors and motor generator sets. To explain why this is so requires a study of the characteristics of the squirrel cage induction motor.

A polyphase squirrel cage induction motor is equivalent to a transformer having a resistance load and secondary capable of rotation. With the rotor blocked the conditions are similar to those present in a short-circuited transformer. The efficiency of the motor is zero and the entire input is lost in the form of heat. The efficiency of the secondary, or rotor, increases with speed until it approaches 100% at no-load speed. The rotor efficiency is equal to

$$(1\text{-}S) \times 100\%$$

where S is the slip, or the difference between rotor and synchronous speeds, expressed as a fraction of synchronous speed. The efficiency of the stator also increases with speed up to a value near normal operating speed but is influenced by the motor design and cannot be simply expressed as a function of the speed.

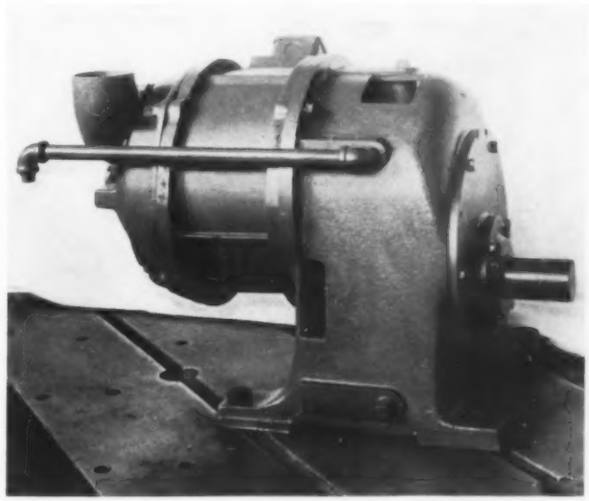
It is known that in bringing a driven load from rest up to rated motor speed by application of rated frequency the rotor loss is equal to the kinetic energy added to the system composed of the rotor and driven load. This can be expressed in watt seconds by

$$.000231 \times WR^2 \times RPM.^2$$

where WR^2 is the inertia of the accelerated system and R.P.M. is the attained speed in Revolutions per minute. It is important to note that the rotor loss is independent of the motor design except as it affects the WR^2 of the system. The stator loss bears a definite relation to the rotor loss dependent upon the ratio of resistance of windings of the two members. The stator loss may thus be influenced and by proper design kept to a minimum.

Recognizing the inefficiency of the motor at high slip, a considerable reduction in the losses during acceleration can be made by the use of variable frequency. Due to the resistance of windings, the starting torque available decreases with decreasing frequency even though the volts per cycle is maintained constant. It is not desirable to start with too low a frequency but the use of a value equal to approximately one-third of the high frequency is satisfactory. For tables designed for variable speeds this usually corresponds to the lowest frequency used and it is comparatively simple to arrange the control to require starting on the base frequency. The control is timed so that the rolls reach a speed approximately equal to that obtained with the low frequency before the frequency is increased. Then the motor generator sets are speeded up at such a rate that the torque required from the motor approximates 150% to 200% of rated torque, but in no case more than the pull-out torque. It is obvious that during this portion of the cycle the motor

Fig. 4—Gearmotor used on table used in figure 3



is operating on a comparatively efficient part of its speed torque curve and at a slip which approaches continuous running conditions. The losses generated are much less than those obtained by acceleration from rest upon application of the final frequency.

Figure No. 5 compares the motor losses and energy input of two different motors for each method of starting. One motor is a 4 pole design while the other is a 10 pole design. There is a decided difference between the two methods, the motor losses for the 10 pole design being nearly 3 times as large when starting at maximum frequency and over 4 times as large when starting at maximum frequency for the 4 pole design. It is true that these particular motors were designed for starting at 20 cycles and that some reduction could be made in the stator losses when starting at high frequency by using a higher rotor resistance. However, the rotor losses cannot be changed and it is evident that it is not possible to design a motor having losses when accelerated with high frequency, as low as those obtained by the use of low frequency starting and then variable frequency acceleration.

The importance of keeping these losses to a minimum is obvious for with a given motor, the number of permissible starts without exceeding a safe temperature is far greater when using variable frequency. The permissible number of starts is approximately inversely proportional to the motor losses.

This method has the further advantage that the input both in KW, and amperes to the motor at starting conditions is considerably less and permits the use of smaller M.G. sets since their size is determined by the energy required in starting.

Figure No. 6 illustrates the speed torque curves of a motor designed for such an application. It will be noted the design is such as to give maximum torque at start and maintain approximately constant torque up to about half speed. This permits getting the equipment up to the low speed in a minimum of time and is accomplished without materially increasing the starting current or stator loss over the minimum possible value. The characteristics of a design made to keep these at a minimum is illustrated by the lower curve. These characteristics are obtained by proper design of both rotor and stator.

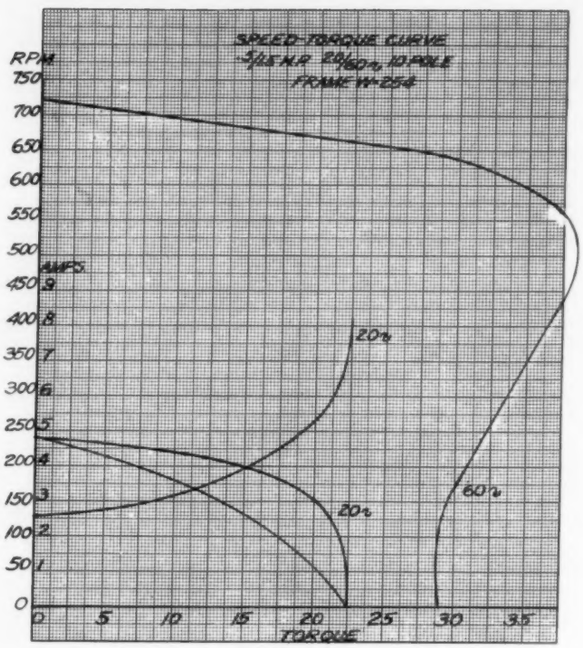


Figure 6 — Speed torque curve of roll table motor with different skew of rotor slots

In this connection it is interesting to observe the influence of skew of rotor slots which is illustrated in Figure No. 7. Curve A is that obtained with a rotor having no skew, i.e. rotor slots are parallel to the length of the core. Curves B and C are obtained with rotors having skews of $\frac{3}{8}$" and $\frac{3}{4}$" respectively. Here the difference is explained by the effect of skew on the motor reactance and illustrates just one of the many factors to be considered in obtaining a desirable design.

In bringing the rolls to a stop using the motor as an

Figure 5—Tabulation of motor losses with different methods of acceleration

Motor	Method of Acceleration	Locked Rotor	Input To Motor	Energy Added To System	Losses In Motor
		Volt-Amperes	Watt-Seconds	Watt-Seconds	Watt-Seconds
5 H.P. 4 Pole W-284	A	46,500	61,100	21,100	40,000
	B	7,450	29,850	21,100	8,750
1.5 H.P. 10 Pole W-254	A	11,900	9,870	3,370	6,500
	B	2,100	6,655	3,370	2,285

A—Started by application of High Speed Frequency.
B—Started by Low Frequency then accelerated by Variable Frequency to High-speed.

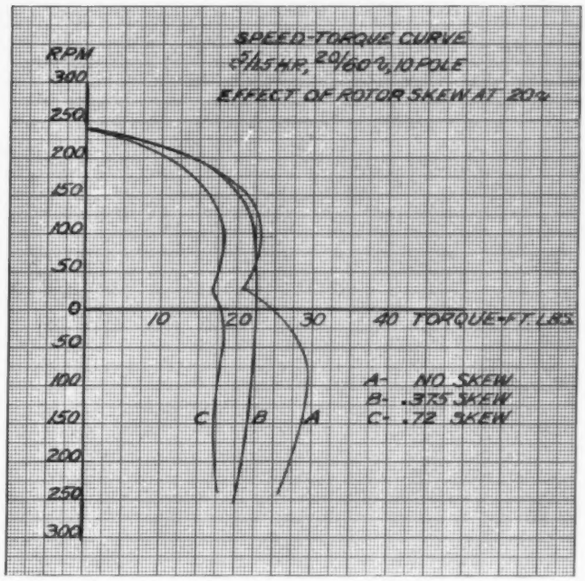


Figure 7—Speed torque curve of roll table motor with different skew of rotor slots

electrical brake, there are several methods available. One method involves plugging the motors with high frequency. A second method uses D.C. current and employs what is frequently referred to as dynamic braking. A third method requires the lowering of frequency to some low value and then plugging the motor at the low frequency. A fourth method differs from the third only in that the plugging with low frequency would be replaced by D.C. dynamic braking. The order of magnitude of losses and input is the inverse of the order of listing of methods given above. This is illustrated by the data given in Figure No. 8.

Here, as with acceleration, the disadvantage of plugging is that the rotor is extremely inefficient. The rotor losses alone are three times what they were during acceleration and they cannot be influenced by motor design. The stator losses can be influenced by the use of a proper ratio of rotor and stator resistances, but they cannot be reduced to anything near the values obtained by the D.C. dynamic braking or variable frequency. D.C. dynamic braking has the advantage over plugging in that the rotor is operating over the same range of slip as it did during acceleration. In other words, upon application of D.C. to the stator while the rotor is rotating at a definite speed let us assume 1750 RPM., conditions in the rotor are similar to those occurring when the motor supply is A.C. and the slip in RPM. is equal to 1750 RPM. However, the stator current with D.C. excitation is constant in value whereas the A.C. current increases in magnitude with increasing slips. Consequently, the shape of the speed torque curve with D.C. excitation does not have the same shape as that with A.C. excitation. The shape is influenced by rotor resistance and reactance. Representative curves are shown in Figure No. 9. Here the curves are of three motors that differ only in the skew of the rotor slots and illustrate the effect of reactance. The curves shown are test values taken with a D.C. current on two phases of the winding equal to 1.65 times normal A.C. full load current and the maximum torque produced is greater than the A.C. starting torque

Figure 8—Tabulation of motor losses with different methods of deceleration

Motor	Method of Deceleration	Locked Rotor	Input To Motor	Energy Taken From System	Loss In Motor
		Volt-Amperes	Watt-Seconds	Watt-Seconds	Watt-Seconds
5 H.P. 4 Pole W-284	A		76,400	21,100	97,500
	B		14,000	21,100	35,100
	C		— 3,350	21,100	17,750
	D		—12,330	21,100	8,770
1.5 H.P. 10 Pole W-254	A		16,790	3,370	20,160
	B		2,650	3,370	6,020
	C		—435	3,370	3,805
	D		—988	3,370	2,382

A—Plugged at High Speed Frequency.
B—Stopped by D.C. Braking.
C—Slowed down with Variable Frequency, then plugged at Low Frequency.
D—Slowed down with Variable Frequency, then stopped with D.C. Brake.

at 20 cycle. These curves indicate that there is a very decided increase in torque of the range in speed represented from 20 cycles down to the low speed. Therefore a combination of deceleration by changing the speed of the motor generator set down to 20 cycles where we have the normal A.C. pull-out torque of the motor available and then transfer over to D.C. dynamic braking where the amount of torque obtained by dynamic braking is a maximum, we have a combination of high torques with the minimum of losses and thus get a maximum rate of deceleration with the minimum amount of loss in the motor and with the amount of power required for dynamic braking kept to a minimum.

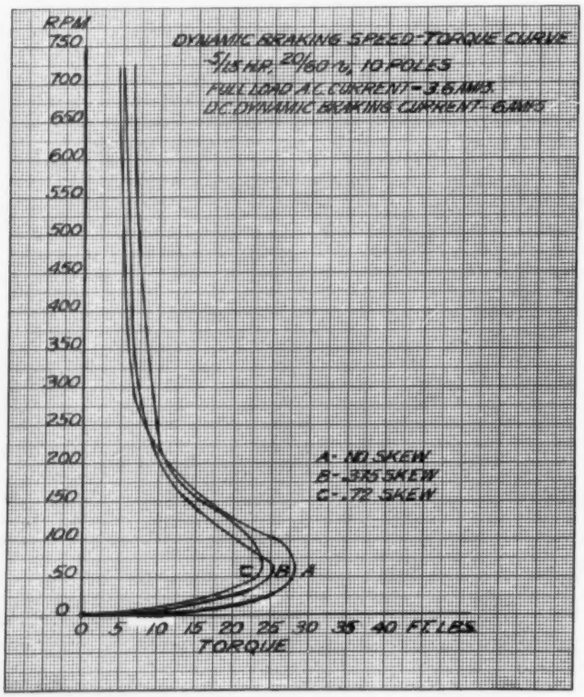


Figure 9—Speed torque curves of D.C. dynamic braking

As mentioned previously with regard to acceleration, the use of variable frequency has the outstanding advantage that it is operating the motor on an efficient portion of its alternating current speed torque curve.

With the method of operation as described, the size of the set is determined by the starting requirement of the motors when they are connected to the generator with the motor generator set running at base speed. In some cases, in order to reduce the requirement of the M.G. set, the motors that receive power from a given set are divided into two or more groups and started in sequence allowing one group to come up to speed before the next group is connected. This method is satisfactory for continuous running tables where the time of acceleration is not important. However it should be avoided when the time of acceleration is important or on tables where they are frequently started and stopped with material on the tables. Quite often, the group starting is used where the motor generator set is allowed to run at constant speed to match the delivery speed of the mill. The possible methods of starting the motors are as follows:

(a) Motor Generator set running at constant speed and all motors connected in one group.

(b) Motor Generator Set running at constant speed with motors connected in two or more groups in sequence with a time delay between groups, to allow each group to reach full speed.

(c) Motor Generator Set running at base speed with motors connected in one group and then accelerate the motors by accelerating the motor generator sets.

(d) Motor Generator Set running at base speed with motors connected in two or more groups in sequence and then accelerate the motors by accelerating the motor generator set.

With the various methods of starting, the requirements of the set vary in the inverse order of the methods named. Figure No. 10 gives the starting characteristics of a typical roll table motor and the starting requirement of a motor generator set supplying power to 100 of these motors. The starting requirements for both the D.C. generator and the D.C. driving motor are very high for the first method and it is evident that either the group starting or starting at low frequency is very desirable. Here again the data is based on a motor designed for low frequency starting and the starting requirements for the first method could be somewhat reduced by the use of a motor with higher rotor resistance. The main advantage of the low frequency starting over the high frequency starting is that the peak load on the D.C. driving motor is greatly reduced being approximately 25% of the value required

Figure 10—Tabulation of starting requirement with various methods of starting

MOTOR CHARACTERISTICS

Frame	W-284	W-284
H.P.	1.67	5
Cycles	20	60
Poles	4	4
Volts	147	440
Starting Amps.	29.2	61.1
Starting Kva.	7.43	46.5
Starting Kw.	6.56	30.4
½ Load Amps.	4.3	5.0
½ Load Kw.	.67	2.5

STARTING REQUIREMENTS OF 100 OF THE MOTORS LISTED ABOVE

Method of Starting	Starting Amperes	Starting Kilowatts
A	6110	3040
*B	2372	1201
C	2920	656
*D	1261	264

*It is assumed that motors are divided into 3 groups. Starting requirements are based on starting last group with 2 groups running at ½ load.

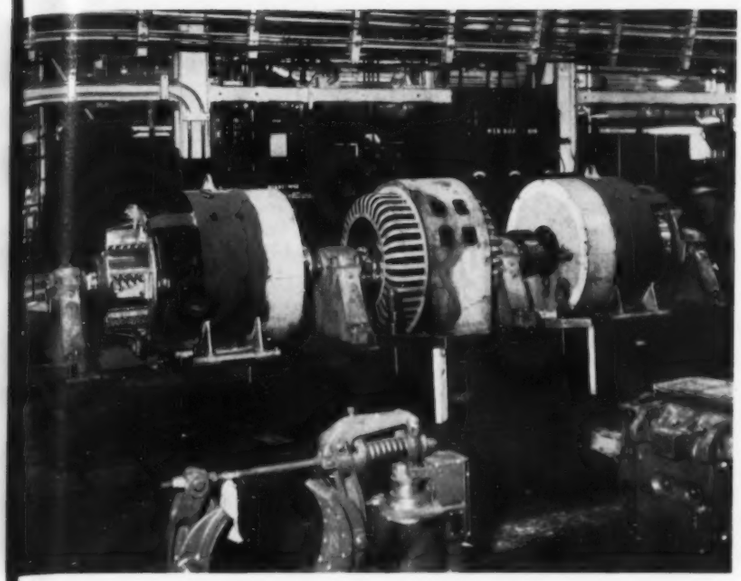


Figure 11—Shop view of 3 unit variable frequency motor generator set

for high frequency starting and approximately 50% of the value required for high frequency group starting. Starting at 60 cycles not only makes the peak load on the D.C. driving motor much greater, but it makes it receive this peak at weakened field and it is a well known fact that D.C. adjustable speed motors can better commutate peak loads when running at base speed than at weakened field speed.

Since the starting KVA. requirements of the motors are several times the running KVA. requirements, the continuous running rating of the motor generator sets are not important. Therefore both the generator and the motor are designed to successfully handle peak currents and the D.C. motor is designed primarily to be able to commutate the peak loads when the motors are connected to the A.C. generator and for the loads received during acceleration and deceleration.

Since rapid acceleration and deceleration is important, it is necessary to reduce the WR^2 of the motor generator set to a minimum. This is accomplished by building the A.C. generator with a small diameter and long core. The same procedure is also followed on the D.C. driving motors, and on larger sets two motors are supplied instead of one. The supplying of two motors has not only the advantage of keeping the WR^2 to a minimum but permits the connecting of the two armatures in series and thus keeping the voltage on the commutator to a minimum.

Figure 12—Installation view of variable frequency motor generator sets

Quite often on large strip mills of this type, the power for the variable frequency M.G. set is supplied from the same generators that supply power to the finishing stand of the mill and this power supply is always 600 volts. Therefore with the two commutators connected in series the voltage on the commutators are 300 volts which makes the problem of commutation during acceleration and deceleration much simpler.

Figure No. 11 shows a shop view of such a set and is one of six duplicate sets being supplied for a mill now under construction and is rated at 500 KVA., 440 volts at 1200 RPM. Figure No. 12 shows an installation view of variable frequency equipment. However in this case power was supplied from a 250 volt auxiliary power source and two unit sets were used. You will note that these sets are strictly a heavy duty steel mill design and industrial type equipment is not used.

Figure No. 13 shows a two unit dynamic braking motor generator set rated at 200 KW., 75 volts and it is of the same general construction as the variable frequency set. This set runs continuously at constant speed so that WR^2 is not important. However, the load is very intermittent and so this set is also designed to handle peak loads of short duration and the continuous rating of the set is not important.

Considerable time has been given to a discussion of electrical characteristics and methods of operation.

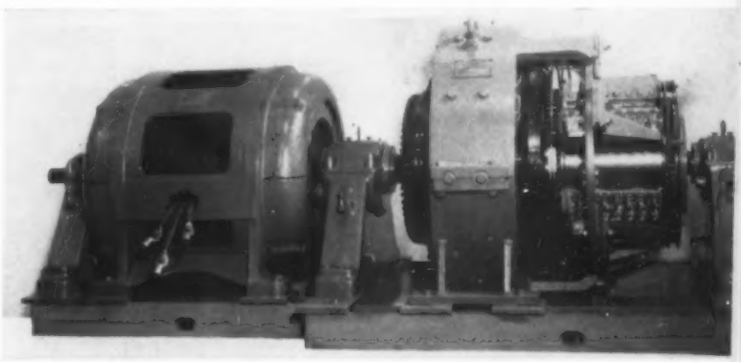


Figure 13—Shop view of a 200 KW. dynamic braking motor generator set

The correct mechanical characteristics are also very important and we wish to call your attention to certain points. Figure No. 14 shows a totally enclosed fan cooled motor arranged for flange mounting with a pinion mounted on the motor shaft to drive the two rollers through suitable gearing, the table being of the construction shown in Figure No. 3.

This motor is completely enclosed and protected so that dust or water cannot reach the windings. The construction is entirely satisfactory for outdoor service and does not require any additional protection. The frame is of cast iron and is rigidly constructed so as to be capable of withstanding severe vibration while maintaining the air gap true. The bearing brackets are made of cast iron strongly reinforced by ribs to provide rigidity and additional cooling surface. A cross section

view of the motor is shown in Figure No. 15. The stator leads are sealed with gum where they leave the frame. The aluminum alloy fan is keyed to the shaft and has a split hub tightly clamped to the shaft by bolts. This permits easy removal of the fan without the aid of a puller when the bolts are loosened.

The point at which the shaft leaves the enclosure is sealed by a cartridge type bearing housing which permits removal of end bracket for inspection of the interior of the motor while the bearings remain sealed, protecting them from dust and grit. It has been recognized that excess grease causes bearings to overheat, due to churning of the grease and there is no way to tell as to the quantity of grease in the ordinary ball bearing assembly unless it is opened for inspection. With this assembly, new grease may be put into the bearing as desired which in turn forces the old grease or excess grease into an overflow sump in the bracket where it can be readily removed through a cleanout plug provided for the purpose. This construction effectively prevents over-greasing or forcing grease into the motor winding and makes the practice of opening the bearing housings each year to clean out old grease unnecessary. A regular schedule for greasing may be followed which will provide the bearings with fresh grease at all times, thereby lengthening their life and reducing maintenance costs. This bearing assembly is also suitable for oil lubrication. Oil fed at a very slow rate through a wick of wool yarn or felt placed in a feed pipe attached to the bearing housing at the point otherwise used for the introduction of grease, furnishes the bearing with a continuous supply of lubricant. Assurance of a continuous supply makes it unnecessary to have an appreciable surplus of oil in the bearing at any time, thus avoiding churning and vaporizing of oil and the possibility of escape into the motor. As each drop of new filtered oil enters the bearing a surplus drop of oil escapes through the discharge port and into the sump below the bearing, where it may be drained when convenient.

Figure 14—Flange mounted totally enclosed fan cooled roll table motor

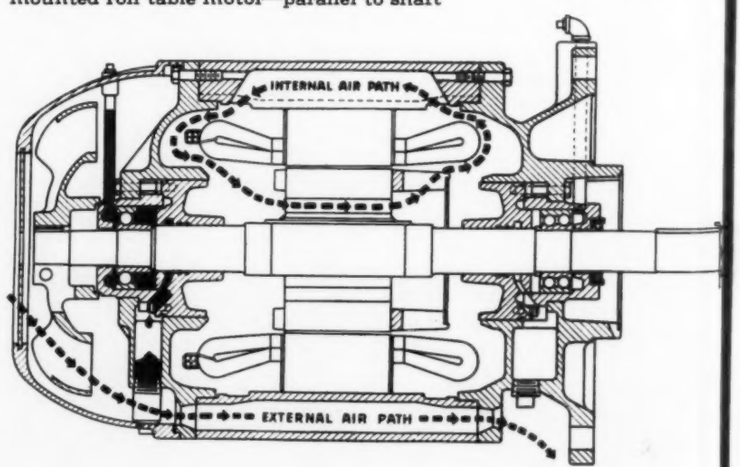
It is desirable to protect the motor windings from dirt, moisture and fumes in the air which means that the motor has to be totally enclosed. In order to dissipate the losses generated by the duty cycle, an efficient method of ventilation is necessary. The dual method of ventilation which has been developed circulates both internal and external air through the motor frame. The frame is cast and contains two separate sets of ducts as indicated in Figure No. 16. One set of ducts is connected to the inside of the motor while the other set connects to the outside. The hot air inside the motor circulates through the internal air duct and the heat is conducted through the frame to the external air duct through which cool outside air is circulated. The cool air circulating through the external air duct not only removes heat from the air in the internal duct, but removes heat directly from the primary core with which it is in intimate contact. However, the external air does not come in direct contact with the primary core which prevents any moisture of corrosive fumes in the air reaching the primary core or the winding.

The arrows in Figure No. 15 show the course taken by the ventilating air. Cool air is drawn in at front end of the motor and circulated over the brackets and through the external ventilating ducts. An internal fan drives air through the rotor core vent holes around the stator coils and through the internal ducts over the stator core, thus continuously circulating air within the motor so that there are no dead air spaces and heat is being continuously carried away from the electrical parts. This type of construction affords a very efficient form of ventilation.

A very important feature of a roll table motor is the stator insulation. Such parts of motor insulation as mica, paper, treated cotton tape, and asbestos are comparatively weak mechanically and do not readily permit sturdy fabrication. These items require considerable skill in design and manufacture to increase their life to values approaching that so easily obtained from the more rugged parts such as the frame, cores and shaft.

Motors of the size used on roll tables employ partially closed slot windings, referred to as "Mush Windings". The coils themselves are wound on moulds or pulled into shape for correct winding in the slots.

Figure 15—Cross section view of totally enclosed fan cooled flanged mounted roll table motor—parallel to shaft



The insulation to ground consists of a slot cell which lines the slot completely with the exception of a narrow opening at the top corresponding to the opening in the slot. Since each slot cell is made by suitable dies, the cells fit the slot absolutely. A poor fit at the bottom of the slot is certain to result in a break in the cell and eventual grounding of the winding. Proper insulating materials are supplied by the use of material having high dielectric value while sufficient mechanical strength is obtained by the use of a tough paper. The two materials are cemented together, since this method gives greater strength, and is more economical of materials and slot space than when the two materials are assembled separately in the slot. Also this method eliminates wrinkles that tend to form air pockets causing hot spots. The ends of the slot cells are protected by a cloth covering that is sewn in place. This is an item of no small importance as it keeps the cell from being torn when the coil ends are shaped in place.

Proper seal is provided at the top of slot by using a U shaped wedge designed to provide long creepage distance from the wires to the steel laminations. Insulation between coils in the same slot is obtained by the use of a U shaped wedge made of the same material as the slot cell. The U shape assures that no stray wires from one coil come near those of another. Tape is applied to the end turns of all coils and is tucked to the slot cells to make a thorough seal. Additional protection is provided between phases. The completely wound stator is first treated in a high temperature oven to remove all moisture, then it is given two distinct and separate treatments of insulating compounds and baked in a high temperature oven after each treatment. The first treatment is highly resistant to moisture, mild acids, and alkalies. The second treatment is highly resistant to oil, grit, and moisture. The windings are left with a tough flexible finish which withstands the effect of expansion and contraction in operation.

Where operating temperatures permit, Class A insulation is used and is good for continuous operation with a hot spot temperature of 105° C. Where higher temperatures are encountered Class B insulation is used.

This motor represents the ideal in roll table construction. It has the proper characteristics to give the duty cycle desired with the minimum amount of motor loss. It has a carefully assembled and insulated winding to prevent insulation failures. It is totally enclosed to prevent the entrance of dirt and abrasive material. The bearings are carefully sealed to prevent dirt getting into the bearing and preventing grease from getting into the motor. It is provided with an efficient system of dual ventilation to remove the motor losses and assure a low operating temperature. It is provided with a heavy duty cast iron frame to withstand the severe mechanical service met on all roll table drives.

Although we do not intend to discuss coiler motors and their application in detail, we wish to point out that in reality, they are really a group of roll table motors with larger ratings due to the fact that they have to exert larger torques and must accelerate and decelerate larger masses of material. These motors

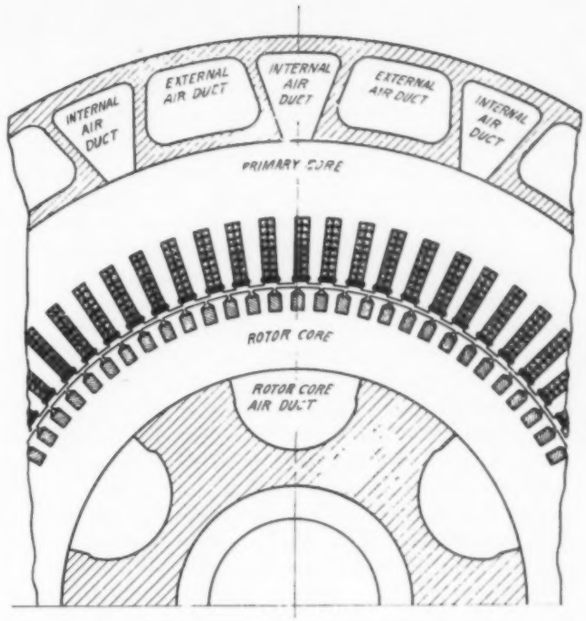


Figure 16—Cross section view of a dual ventilated totally enclosed fan cooled motor showing system of ventilating ducts

also receive more mechanical abuse and are subjected to a large amount of moisture. Figure No. 17 shows a United Engineering & Foundry Company coiler with special flanged mounted motors. The motors are limited in diameter, the dimension being determined by the inside diameter of the coil. Consequently, it is necessary to increase the length of the motor to obtain the necessary torque. These motors are of the fan cooled construction and have all the mechanical features of the roll table motors just described.

On practically every roll table installation, the question of the method of overload protection for the individual motors and also the method of installation of this overload protection arises. Most operating men agree that some sort of simple manually operated device with an automatic overload trip is desirable, although this device must be rugged and reliable so that its maintenance will not cause more trouble than the occasional replacement of a burnout motor. Such a device is shown in Figure No. 3.

While roll table motors can be actually burned out due to a severe duty cycle operation which cannot be protected by a disconnecting switch of this kind, the switch does definitely protect the motor against any failure which tends to stall the rotor. On a table of this type where hot material is being handled, it is possible to stall the roll either by warping or by the strip jamming between the roll and the apron plate. The overload trip device can be easily set so that it will trip in 10 or 15 seconds on stalled rotor conditions or in a longer time on excessive overloads and will still permit frequent acceleration and deceleration of the table.

The roll table shown is of unit construction, and when a section is removed the motor is included. How-

ever, it is necessary to disconnect the motor leads from the power supply. The use of the disconnect switch makes it easier to disconnect this motor from the power supply as the leads are disconnected at the switch unit, the long lead and the flexible conduit being removed with the motor.

On the installation shown in Figure No. 3 no water is used, but on some installations a large amount is present. On an installation of this type a construction as indicated in Figure No. 18 is recommended. The disconnecting switches either 2 or 3 in number are located in a cast iron weather-proof box so mounted that the conduit carrying the power supply leads are connected directly from one box to the other. The main power leads then run directly from the conduit through the box and into the conduit, etc. The motors themselves are supplied with water-proof conduit boxes and a water-proof connection is made between the conduit box and the water-proof switch box. This type of installation has the advantage that it is often a very simple and inexpensive conduit arrangement as well as protecting the disconnecting switches.

The disconnecting switch protects the motor against most of the unusual conditions which will be met in service. However, it is possible to subject the motors to a duty cycle that will not trip the switches, but if continued for a considerable length of time, will burn out the motors. To protect against such a condition, a few of the motors on each table can be equipped with an imbedded thermoguard which measures directly the temperature of the motor winding and will trip when dangerous temperatures are reached. These thermoguards are then connected in series with an indicating light on the operator's control desk and will warn him when a dangerous temperature is reached. This method of motor protection will be installed on one of the wide strip mills now under construction.

This completes our discussion of the electrical roll table equipment. We hope that our comments have emphasized the importance of the proper coordination of the various units required. The motors must be both electrically and mechanically designed for the particular application. The motor generator sets must be matched to the motors and deliver the power required by them to meet the operating conditions. The control must be designed to give the operator a simple and flexible unit and yet control the motors and the motor generator sets so that they will do the job with the minimum amount of losses in each unit. The control equipment must also fully protect the equipment to prevent failures in operation which would delay production.

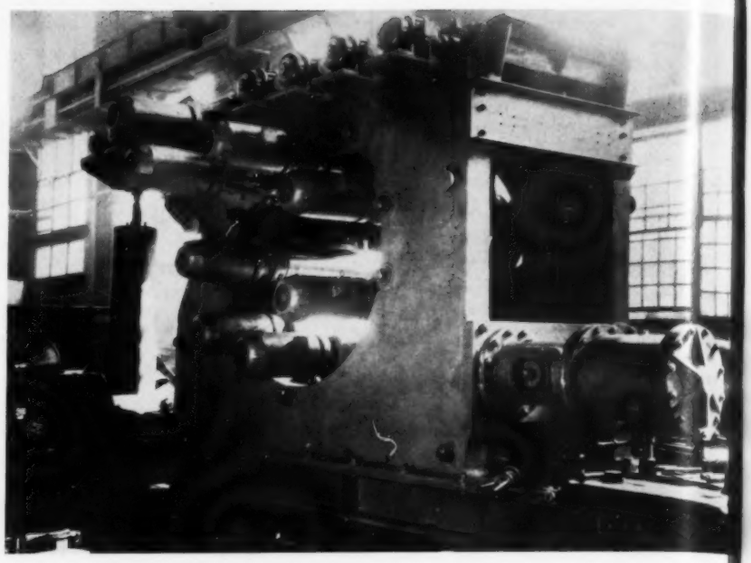
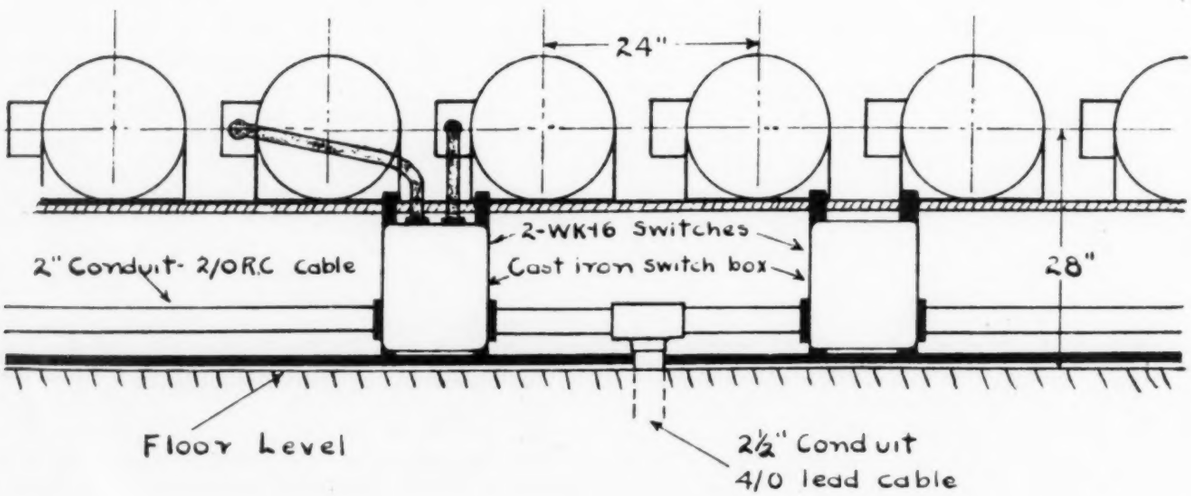


Figure 17—Factory view of United Engineering & Foundry Company wide strip coiler

Figure 18—Conduit arrangement and disconnecting switches for roll table motors.



DISCUSSION*

PRESENTED BY

J. FARRINGTON, Electrical Superintendent, Wheeling Steel Corporation, Steubenville, O.

B. A. SHRIVE, Asst. Elec. Supt., Steel Company of Canada, Ltd., Hamilton, Canada.

A. M. MacCUTCHEON, Engineering Vice President, The Reliance Electric & Engineering Company, Cleveland, Ohio.

J. W. BATES, American Sheet and Tin Plate Co., Pittsburgh, Pa.

W. B. SNYDER, General Electric Co.

J. Farrington: We have found it very desirable to put over-load devices on each one of the coiling motors. When the coil once enters the coiler, you can stop one, and in some cases two motors and still coil your strip.

B. A. Shrive: In connection with run-out table motors it may be possible that some of the operating men present would be interested in an experience we recently had. The system had been installed and operating about four years without any trouble, and included three 200 Ampere fused main circuits to consecutively wired run-out motors, and for some reason, possibly a loose link, one of these fuses opened up due to heating. This happened on a day when the mill ran continuously without shutdown, allowing the group of motors on this circuit to continue running single phase, and out of the group we lost or seriously damaged about twenty motors. The fuses have been replaced on all three circuits by three pole circuit breakers.

J. W. Bates: I would like to ask Mr. Snyder two questions: First, as to the advantages of frequency control in rapidly decelerating table rolls.

We saw, from the curves shown that with frequency control that there is more torque available for stopping the tables at the higher frequencies than there is with dynamic braking which theoretically permits the tables to be brought to rest in a shorter period of time.

Now is it possible to actually secure this saving in time? Is there any test data showing the co-efficient of friction and thus the maximum rate of deceleration without skidding the steel on the rolls, or is it possible to secure sufficient torque by dynamic braking to stop the tables as rapidly as possible without skidding the steel on the rolls. If this can be done with dynamic braking, what is gained by using a more complicated method providing more torque than can be used? Calculations using co-efficients of friction on steel wheels or rails indicate that dynamic braking provides all the torque that can be used. Is there available any test data on co-efficients of friction or permissible rates of deceleration to make possible an accurate answer on this point?

The second question is: In just what range of accelerating time is "frequency control" superior to the standard practice?

That is, on old installations where a relatively long acceleration time was permissible "frequency control" was not required. But on the installation very recently made "frequency control" is advocated as permitting faster acceleration.

However, is there not a point of still shorter accelerating time where "frequency control" would not be satisfactory? If it is required to accelerate a table from rest to full speed in two seconds obviously to do this by frequency control is not feasible with any "reasonable" design of set as the WR^2 of the set would necessitate a very large accelerating torque—(unreasonably large driving motors). Now if the table is divided into say six groups of motors and each group thrown on the set at two second intervals (or slightly less) the first section will be up to speed in two seconds and each succeeding section up to speed two seconds later but before the strip reaches that section.

W. B. Snyder: In answer to Mr. Bates' question, the minimum decelerating time can not be obtained by dynamic braking. Very high torques, even enough to break the motor shaft can be developed, but, due to the shape of the speed torque curve, the average dynamic braking torque is only a fraction of the maximum torque. The maximum overall rate of deceleration of metal on a table would be obtained with a value of braking torque almost high enough to cause slippage, maintained constant from top speed to rest. The nearer this condition is approached, the faster the material on the table will come to rest. Constant torque during deceleration is approximated much more closely by plugging than by dynamic braking, as may be seen from the curves previously shown.

A. M. MacCutcheon: The Association is greatly to be congratulated on the excellence of these two papers that have been presented on the subject of runout and roller table drive. The subject is much in the minds of all steel mill electrical engineers in connection with the installation of the several new large strip mills throughout the industry. Within the Association records, is being compiled a large amount of valuable information, starting with the paper presented by Mr. Harrell last fall.

The suggestion is offered that one or two papers by operating men in the mill would be a particularly valuable addition. In the last analysis it is the actual result secured in the mill that gives the correct answer.

The papers which have been presented this morning are so excellent in their logic that no exception can be taken to the statements which are contained in the papers. However, if different assumptions were made, different conclusions might result. Output from the mill is the primary consideration, and that system which best serves the mill, is the one which is to be preferred. Increased losses within the table motors

(Continued on page 58)

* This is a discussion of both Mr. Snyder's and Mr. Caldwell's paper.

DEVELOPMENTS IN ROLLING

FLAT STEEL PRODUCTS DURING 1935

By STEPHEN BADLAM
Consulting Engineer
PITTSBURGH, PA.

Paper presented before the A. I. & S. E. E. Convention. Pittsburgh, Pa., September, 24, 25, 26, 1935

INTRODUCTORY

▲ AT THE FALL MEETINGS, of this Association, for the past two years, the author has presented papers the purpose of which was to outline the developments in the art of Flat Steel Rolling, up to that time.

The present discussion is intended to supplement these two papers by describing briefly some of the major developments that have taken place since the last meeting.

GENERAL

In general, the outstanding feature has been the number of Hot Broad Strip Mills, placed in operation, under construction, and authorized, during the period. Secondary only to the hot mill construction, has been the number of cold strip mills, particularly for the production of wide, full finished sheets, now under way. The number, as well as the capacity of these mills far exceeds that of any period of like extent.

HOT BROAD STRIP MILLS

In addition to the one Continuous Sheet Mill, and eleven Hot Broad Strip Mills, built during the period from 1923 to 1932, inclusive, there have been nine new mills, four of which were started, or about ready to start, during the year 1935, and five more, under construction, and expected to go into operation in 1936.

Two mills, the first completely new, and the other a reconstructed and enlarged mill, of an older type, went into operation during the first nine months of 1935.

79″	Youngstown Sheet & Tube Co.	Campbell, O. Mar. 12.
38″	Carnegie-Illinois Steel Corp.	Gary, Ind. Aug. 3

Two other mills are scheduled for starting during the remaining three months.

56″	Ford Motor Co.	Dearborn, Mich.
43″	Carnegie-Illinois Steel Corp.	McDonald, O.

There are now under construction, and scheduled for operation in 1936.

79″	Bethlehem Steel Co.	Lackawanna, N. Y.
79″	Great Lakes Steel Corp'n	Ecorse, Mich.
80″	American Sheet & Tin Plate Co.	Gary, Ind.
84″	Granite City Steel Co.	Granite City, Ill.
100″	Carnegie-Illinois Steel Corp.	Homestead, Pa.

In addition to the twenty one mills mentioned, as built, or under construction, in the United States, there is now under construction, one additional mill, for the Zaporojstal Works, U.S.S.R. It is the only mill, of the type, at present definitely determined upon, outside of the United States.

It is further reported that at least three additional mills, in the United States, are now under consideration.

CAPACITY

The total annual capacity of the nine new Hot Broad Strip Mills, in the United States, is approximately 4,500,000 tons, equalling or exceeding the combined capacity of the previously built mills, and bringing the capacity for this type of flat rolled product to a total of approximately 9,000,000 tons annually.

GEOGRAPHICAL DISTRIBUTION

The geographical distribution of the Hot Broad Strip mills will be somewhat extended by the addition of the new mills. That is to say, one or more mills will be added to the existing Pittsburgh, Chicago, and Detroit Districts, the Bethlehem Mill will add a new Buffalo District, and the Granite City Mill, a new St. Louis District, see Fig. 1.

CAPITAL EXPENDITURES

It is interesting to note that the major improvement projects in the steel industry, under way, or authorized in 1935, have been for flat rolled steel production. Of well over $100,000,000, so far expended, or appropriated, over 90% has been for this class of product, and for mills of the Broad Strip Type.

DESCRIPTION OF NEW MILLS

The hot strip mills of the Youngstown Sheet and Tube Co., at Campbell, Ohio, and of the Ford Motor Co., at Dearborn, Mich., were somewhat fully described in the paper of last year and therefor need no further mention here.

43" HOT STRIP MILL
CARNEGIE-ILLINOIS STEEL CORP.
McDONALD MILLS, McDONALD, O.

During the last half of the year, 1934, the United States Steel Corporation approved an appropriation for its subsidiary, the Carnegie-Illinois Steel Corporation, for the construction of a Continuous Strip Mill at their McDonald Mills in the Youngstown District.

Ground was broken for the construction of this Mill on Jan. 17, 1935.

The buildings housing the Mill and its auxiliary equipment cover an area of approximately eight acres.

The preparation of the site and foundations required 48,000 cubic yards of excavation; 38,000 cubic yards of concrete; 1,900,000 pounds of reinforcing steel; and 150,000 cubic yards of slag fill.

The construction of the Mill building required 11,000,000 pounds of structural steel; and 1,250,000 pounds of corrugated sheeting.

The Mill buildings are exceptionally well-lighted and ventilated, having 38,000 square feet of skylight; 63,000 square feet of windows; and 46 ventilators of sufficient capacity for 1½ to 6 complete air changes per hour.

The slab storage yard is 110 x 420 ft., in which steel slabs to the extent of 12,000 tons can be stored.

The Mill is served by 3 natural gas fired, continuous-type heating furnaces, each 18 ft. wide by 75 ft. long inside, with sufficient capacity to heat 50 tons of slabs per hour per furnace.

Slabs are discharged from the furnaces onto a delivery table and thence to the Mill, which is of the continuous type, and consists of the following, in the sequence named:

1 Horizontal Two-High Scale Breaker

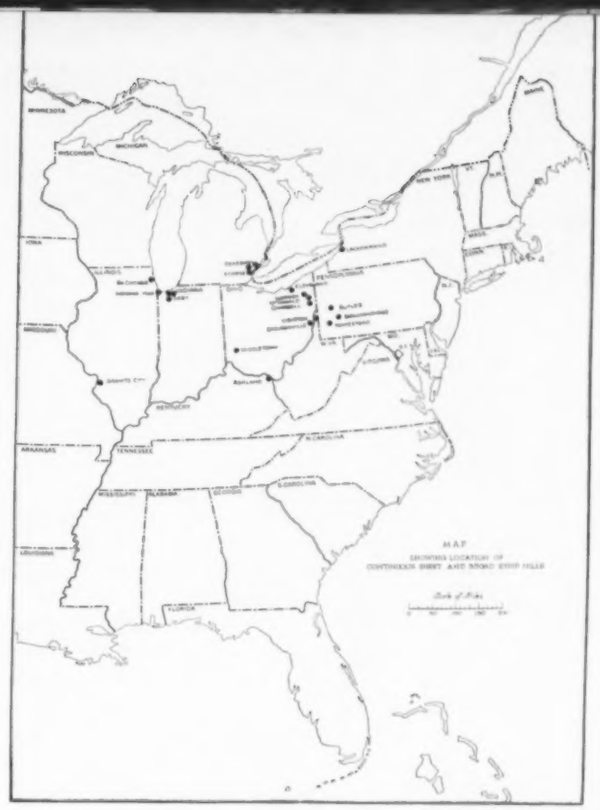


Fig. 1

1 Slab Reducer
3 Two-High Roughing Stands with 1 Vertical Edger
1 Four-High Roughing Stand with vertical edger
1 Delay and Rocking Table
1 Horizontal Two-High Scale Breaker
1 Flying Crop Shear
6 Four-High Finishing Stands
1 Flying Shear for cutting lengths 10′ to 30′
2 Coilers
1 Piler for Cut Lengths

The length of the Mill, including heating furnaces, is approximately 1200′.

All rolls have 43″ wide face and the Mill is capable of delivering rolled product from the finishing stand at the rate of 2000 feet per minute.

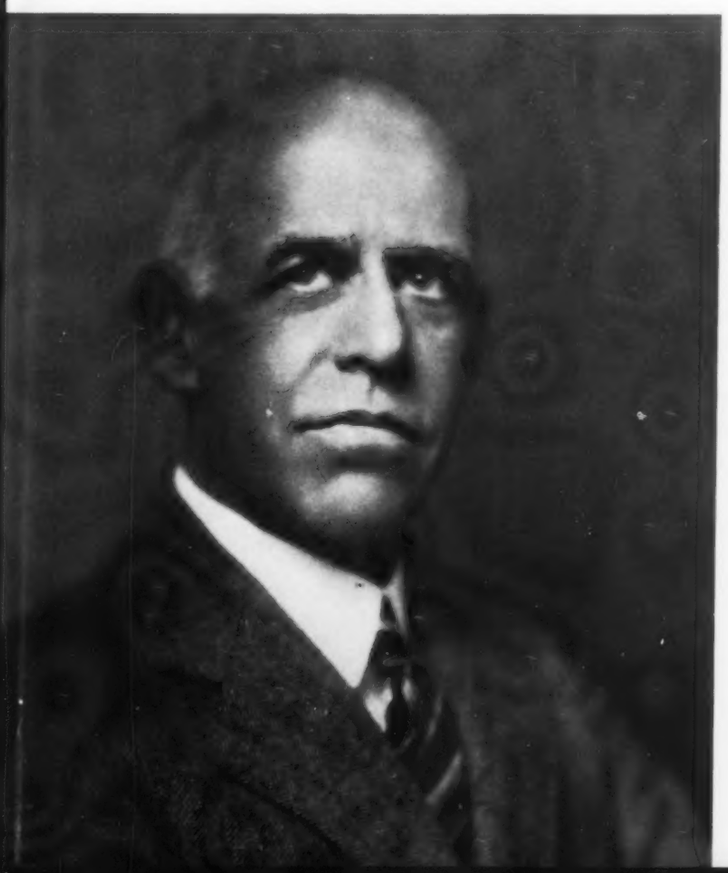
Hot coils from the Mill are conveyed to a storage area in a Coil Storage Building, where they are weighed and allowed to cool. From here they are either loaded into cars for direct shipment or put on another conveyor serving 3 coil processing units. These units can process the coils for prevention of "coil break", trim the edges or slit the coils into as many as 7 multiples or shear into accurate cut lengths.

Hot pack material in lengths from 10 to 30 ft. from the Mill is weighed and placed on racks in Coiler Building for cooling. They are then transferred by either conveyor or electric transfer car to three pack processing units. These units shear the material to accurate cut lengths, trim the edges, or slit the single piece into multiples.

There is additional auxiliary equipment consisting of a 4 arm batch pickling unit, a natural gas fired normalizing furnace, a skin pass mill, a squaring shear, roller levellers, and oiling equipment.

The Mill has 46 Selsyn devices which allow micrometer adjustment of the rolls, guides, etc., and are electrically indicating. They afford a silent thickness indication of the product in all parts of the Mill proper.

STEPHEN BADLAM



The Mill is equipped with pumping equipment and sprays for use in breaking scale as the steel passes through the Mill; water at 1000 lbs. pressure being used for this purpose.

All stands in the mill and the major portion of its auxiliary equipment are driven by individual electric motors, of which there are 765, ranging in size from ¼ to 3500 H. P. For cooling the main Mill motors, 600,000 cubic feet per minute of cleaned air are required.

The buildings are equipped with a total of 12 electric overhead traveling cranes, ranging in capacity from 15 to 60 tons.

Power for operating this Mill is generated at the Ohio Works of the Carnegie-Illinois Steel Corporation, at 6600 volts. It is stepped-up to 44,000 volts by means of transformers and transmitted to the McDonald Mills by 7 miles of transmission line, where it is stepped-down to 6600, 220, and 110 volts by means of transformers. The above 6600 volt alternating current is converted by means of motor generator sets to direct current, 600 and 250 volts.

The product of the Mill is strip steel up to 37 inches wide and in thickness ranging from No. 18 gauge to ⅜", with a capacity of 30,000 tons per month. This material can be supplied in coiled form up to ¼" thick, ranging from 180 lbs. to 300 lbs. per inch of width, or in cut lengths ranging from 30 inches to 30 feet, and up to ⅜ inch in thickness.

Welfare buildings of all steel, insulated construction, and equipped with modern convenience facilities, have been provided for the workmen, as well as cool drinking water fountains in convenient locations throughout the Mill.

The construction of the Mill required 10,100 cars of material, 11 miles of pipe, and 12,000 lineal feet of sewers.

38" HOT STRIP MILL
CARNEGIE-ILLINOIS STEEL CORP'N,
GARY, IND.

No information is available on this mill other than the statement in the U. S. STEEL CORPORATION report for 1934 that: "At Gary, Ind. Works the 28" 2-high strip mill is being converted into a 36" 4-high strip mill."

MILLS UNDER CONSTRUCTION

Of the Mills under construction, two, those of the Bethlehem Steel Co., at Lackawanna, and of the Great Lakes Steel Corporation at Ecorse, Mich., are as far as the mill proper is concerned, substantially identical with the mills of the Inland Steel Co., and of the Youngstown Sheet & Tube Co., previously described. The third, that of the American Sheet & Tin Plate Co., is sufficiently similar, so that a comparison will be of value. All of these mills are designed to produce flat rolled steel of a maximum width of from 72" to 74".

HORSE POWER

There will be noted first, a substantial increase in the connected Horse Power, as shown in the following table:

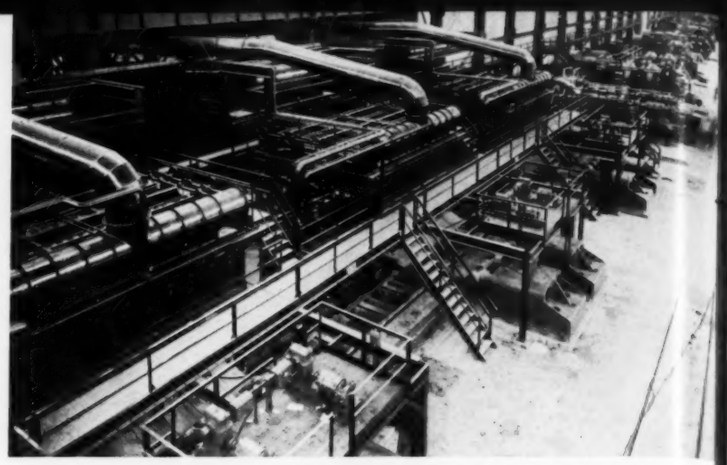


Fig. 2—43" Hot strip mill, McDonald Mills, Carnegie-Illinois Steel Corp. General view of mill from furnace end

Fig. 3—Same; view showing mill proper with slab squeezer in foreground

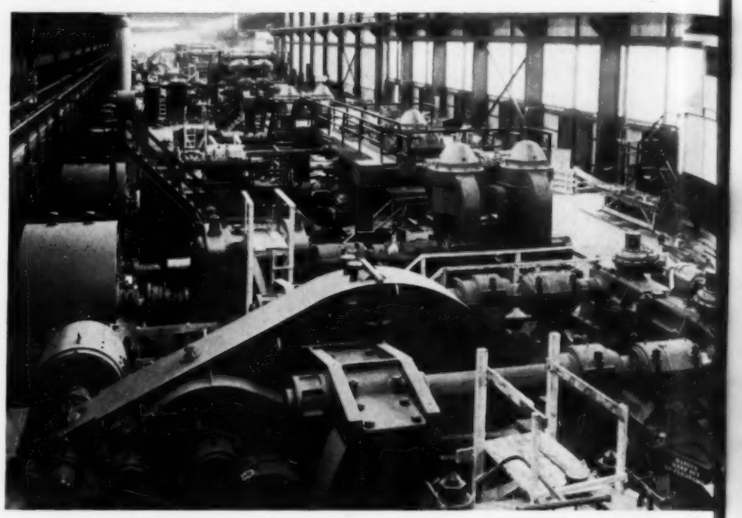
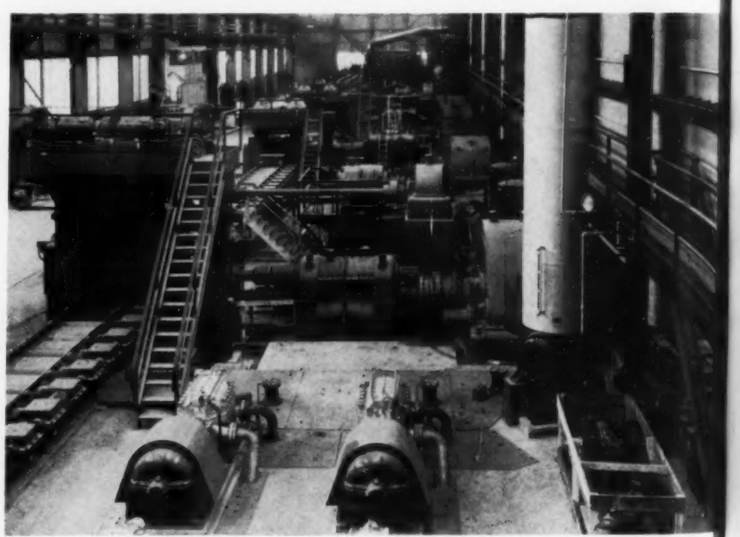
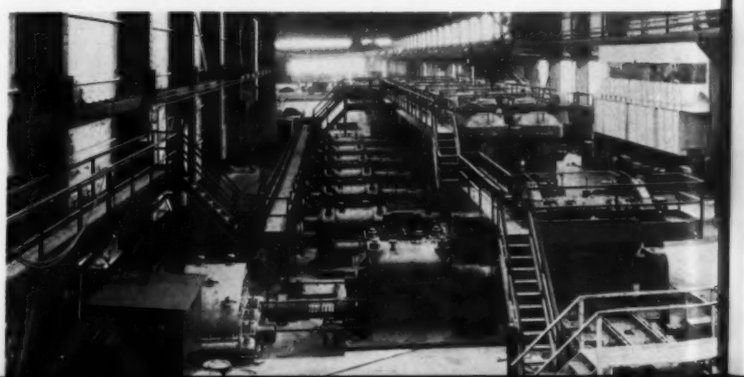


Fig. 4—Same; view showing spray pumps and roughing train to furnace



Figr 5—Same; view showing No. 2 scale breaker and finishing train



ROUGHING	Inland	Y.S. & T.	Bethlehem	Ecorse	A.S. & T.P.
Scale Breaker	1000	1500	1000	1000	1250
Spreader No. 1	3000	3000	3000	3000	3500
Edger	150	150	150	150	300
Rgh. No. 2	3000	3000	3000	3000	3500
Edger	150	150	150	150	300
Rgh. No. 3	3000	3000	3000	3000	3500
Edger	150	150	150	150	300
Rgh. No. 4	3000	5000	3000	3000	3500
Total	13450	15950	13450	13450	16150
FINISHING					
Scale Breaker	500	500	500	500	600
Fin. No. 5	3500	3500	4500	4500	4500
Fin. No. 6	3500	3500	4500	4500	4500
Fin. No. 7	3500	3500	3500	4500	4500
Fin. No. 8	3500	3500	3500	4500	4500
Fin. No. 9	3500	3500	3500	4500	4500
Fin. No. 10	3500	3500	2500	3000	3000
Total	21500	21500	22500	26000	26100
Grand Total	34950	37450	35950	39450	42250

FINISHING SPEED

A second feature of note is the increase in the finishing speeds. The earliest mills built, from the Butler Mill to the Middletown Mill, inclusive, had a maximum finishing speed approximating 1000 F.P.M. The Otis, Inland, and Youngstown Sheet & Tube Co. mills, each had a speed of about 1350 F.P.M. while the new American Sheet & Tin Plate Co., mill will have a speed of about 1750 F.P.M.

Among the new, narrower mills, the Ford Mill stepped the speed up to about 1650 F.P.M., and the McDonald Mill, which has the highest to date, to about 2000 F.P.M.

WEIGHT OF COIL

A third feature of interest is the increase in the weight of the coils rolled. The earlier mills were limited to a coil weight of approximately 1000 lbs. per foot of width. This was gradually stepped up, in the succeeding mills. to about 2000 lbs. per foot of width in the Inland mill, and in the McDonald mill coils of a weight of approximately 3600 lbs. per foot of width may be rolled.

In order to produce these heavier coils it has been necessary to increase the distance between the stands of the roughing, and between the last roughing stand and the first finishing stand. This tendency is specially marked in the case of the Ford Mill and the McDonald mill. In both cases the distance between the roughing and the finishing trains being of the order of 175 feet, or almost double that of the Inland mill.

100″ CONTINUOUS PLATE MILL
HOMESTEAD WORKS

(For description see page 50, column 2)

84″ PLATE AND HOT STRIP MILL
GRANITE CITY STEEL CO.,
GRANITE CITY, ILL.

Announcement of the placing of the order for this mill was only recently made, and no details were given other than that the mill would be equipped to roll plates to 84″, and hot strip to 72″, wide.

58″ HOT STRIP MILL
AMERICAN ROLLING MILL CO.:
MIDDLETOWN, OHIO

The American Rolling Mill Co., recently announced that it would increase to 80″ the width of the 58″ Hot Strip Mill, built at the Middletown Plant, in 1928. This will place the mill in position to roll coils of the maximum width required for the new Cold Strip Mill, now under construction.

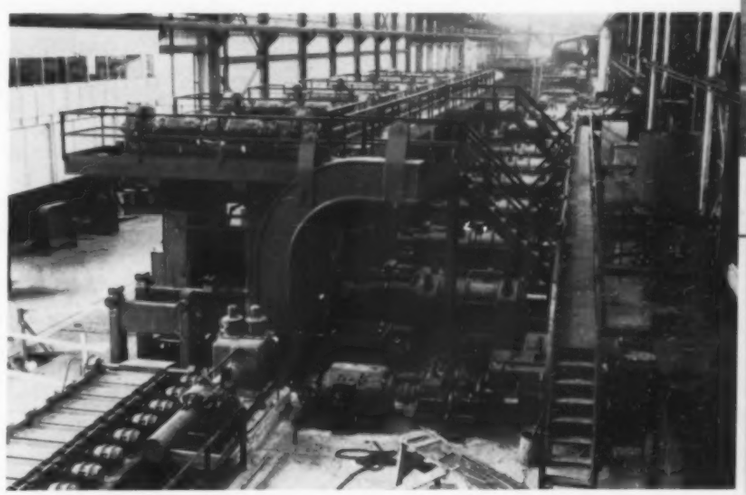


Fig. 6—Same; view showing finishing train from coiler building

It may be of interest to note that of the nine new mills, built, or under construction, four-high stands for two of them were built by the Continental Roll and Steel Foundry Co., and mark the entrance of an additional builder in the field of the four-high Hot Strip Mill.

COLD STRIP MILLS (SHEETS)

The cold strip mill built by the Youngstown Sheet & Tube Co., in connection with the 79″ Hot Broad Strip Mill, went into operation about Aug. 1, of this year, and the cold strip mill of the Ford Motor Co., is expected to go into operation in December. Both these installations were described briefly in last year's paper. Illustrations of the Youngstown Sheet & Tube Cold Strip Mill are given in Figures 7, 8, & 9.

The 38″ mill of the Carnegie-Illinois Steel Corp. at Gary, Ind., and the 43″ mill of the Carnegie-Illinois Steel Corp. at McDonald, Ohio, will not, as far as reported, at the present writing, have cold rolling equipment in connection with them, although they will serve as a source of supply for affiliated cold rolling plants, as well as for the general trade.

The new 100″ Homestead Mill, of the Carnegie-Illinois Corp., while primarily for the production of

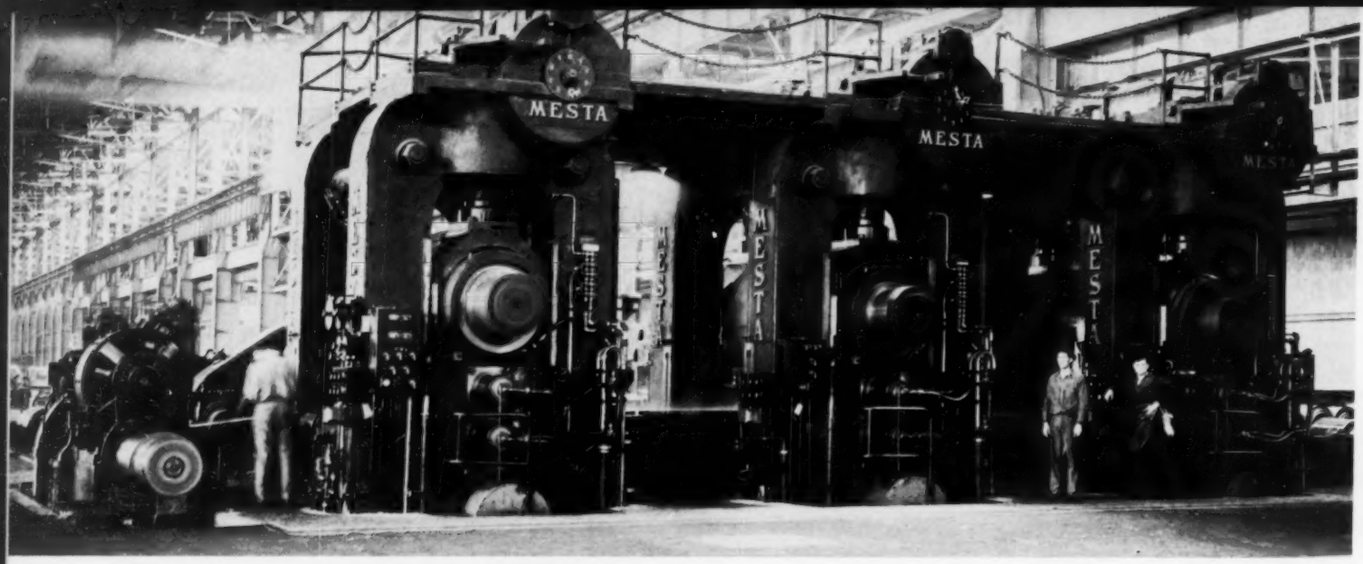


Fig. 7—Cold strip mill, Youngstown Sheet and Tube Co., Campbell. O. Three stand continuous four high mill

plate gages, ¼″ and heavier, will be designed to produce as light as 14 gage. While no cold rolling equipment will be installed, by the operating company, at least at present, the mill will be in a position to produce hot rolled stock, for cold rolling, by others, of a greater width than is possible in any other mill, as yet built, or contemplated.

The following three mills, now under construction:

79″ Bethlehem Steel Co., Lackawanna, N. Y.

79″ Great Lakes Steel Corp'n., Ecorse, Mich.

80″ American Sheet & Tin Plate Co., Gary, Ind.

all will have supplementary cold rolling equipment installed in connection with the hot mills, details of which, however, have not been announced, other than that in the case of the first two, they will be substantially identical with that of the Inland and Youngstown mills.

Both of these installations will probably include two tandem trains, of three stands each, one having a width of 75″ and the other of 54″, equipped with reels, and either one or two single stands likewise equipped with reels. In addition there will be a single stand of 90″, or greater face, without reel, for cross rolling sheets wider than may be produced on the hot mill. Each of the before mentioned stands will be driven by a D.C. adjustable speed motor of 1250 H.P. and 300-600 R.P.M. The reels will each be driven by a 150/225 H.P., 225-900 R.P.M. Motor. Each tandem train, with its reel, will be driven from its own motor generator set. Both installations will have, in addition, one or more skin rolling mills, of the four high type, driven by one 250 H.P. 500-1000 R.P.M. motor on the rolls, and one 125 H.P., 225-900 R.P.M. motor on the reel.

No details as to the cold rolling equipment to be installed in connection with the American Sheet & Tin Plate Co. mill are as yet available.

GRANITE CITY STEEL CO.
GRANITE CITY, ILL.

It is reported that this company will install, in connection with the hot strip mill now under construction, cold rolling equipment, the extent and character of which has not yet been announced, other than that it will include one four-high reversing mill, with two reels, for the production of widths up to 36″.

AMERICAN ROLLING MILL CO.
MIDDLETOWN, O.

Up to the present time the American Rolling Mill Co. at the Middletown Plant has been producing substantially all of its thin gage, sheet width material from breakdowns, produced on the hot strip mill, and finished on mills of the conventional sheet mill type.

This year, however, appropriation was made for the construction of a plant for cold rolling sheets, in coils, in widths up to 72″, in full finished, auto body, and equivalent quality. A three stand tandem train, equipped with tension reel has been ordered and other necessary equipment will follow. Each of the three stands will be driven by a 1500 H.P. 300-600 R.P.M. motor, and the reel by a 600 H.P. 300-1050 R.P.M. motor.

The following table summarizes the additions to cold rolling capacity, in sheet widths and gages, other than strip for tinning.

COILS	Y. S. & T.	Ford	Bethlehem	Great Lakes	Armco
Tandem	1 of 3	1 of 3	2 of 3	2 of 3	1 of 3
Singles	1	1	2	1	
Skin roll mills	1	2	1	1	
SHEETS					
Single (Cross roll)	1	1	1	1	
Total	6	7	10	9	3
	Grand Total 35 Stands				

To be added to this number will be the equipment for the American Sheet & Tin Plate Co. and the additional stands for the American Rolling Mill Co., which will probably bring the total to well over 40 stands.

It may reasonably be expected that the total annual capacity of the equipment outlined above, for full finished sheets will at least equal the existing cold rolling capacity, in widths from 36″ to 66″, and greatly increase the capacity in widths from 66″ up to 90″.

STRIP FOR TINNING

The production of cold rolled strip for tinning has received a substantial impetus during the year.

The Republic Steel Corp. at the Warren Plant, is adding one four high mill, of the reversing type, with rolls 16″ and 49″ x 42″. This mill will be considerably heavier than the mill of the same type installed last year, and will be equipped with one 1200 H.P. motor on the rolls, and one 300 H.P. motor on each reel. This, it will be noted, represents quite a different distribution of power, between the rolls and the reels, from that of the earlier mills of the two reel, reversing type.

The Jones and Laughlin Steel Corporation, at the Alliquippa Works, is adding another four high mill, reported to be for skin rolling in coils, the product of the mill installed last year.

The Weirton Steel Co., has made substantial changes to the four high tandem mill, installed last year, with an increase in the connected H.P., speed, and capacity. They are also adding an additional tandem train of the same type, but still greater H.P. and speed.

There have been two additions to be the potential producers of cold reduction tin plate during the year.

The Bethlehem Steel Co. is adding a five stand tandem train, together with two skin rolling mills, to the Sparrows Point Tin Mill.

The Crown Cork & Seal Co., of Baltimore, is adding a four stand tandem train, and a single mill, for the production of strip for tinning, for their own consumption.

COLD ROLLED STRIP (UNDER 24″)

In the field of cold rolled strip production, in widths of under 24″ there have been some additions to capacity.

WEST LEECHBURG STEEL CO.

The West Leechburg Steel Co. is adding one 12″ and 33″ x 30″, four high mill, which will be driven by one 800 H.P. 500 to 800 R.P.M. motor on the rolls, and one 300 H.P. 300-1000 R.P.M. motor on the reel. This will be used largely for breaking down wide strip, (up to 26″), and will presumably replace some of the existing two high equipment.

This company also installed, during the year, one additional Steckel Mill, of the 20″ size, making a total of six mills, of the Steckel Type, in the plant.

Fig. 8—View of cold strip mill from finishing end

WALLINGFORD STEEL CO.

The Wallingford Steel Co., installed during the year one four high strip mill, of the reversing type, with rolls 12″ and 33″ x 29″, driven by one 800 H.P., 500-800 R.P.M. motor on the rolls, two 150 H.P., 300-1200 R.P.M. motors, one on each of the two reels.

GREER STEEL CO.

The Greer Steel Co., at Dover, O., has installed an additional four high mill with rolls 13½″ and 30″ x 30″.

DETROIT STEEL CORP'N

The Detroit Steel Corporation at Detroit, Mich., installed one 10½″ and 26″ x 24″ four high cold strip mill of the reversing type.

The illustration, Fig. 10 may be taken as illustrative of the class of construction of most of the newer installations.

RING TYPE MILLS

Three mills of the so-called Ring Type, have been built in this country, during the year.

These mills, the design of which originated in Sweden, some ten years ago, comprise essentially a three high mill, with small middle roll, the top and bottom roll

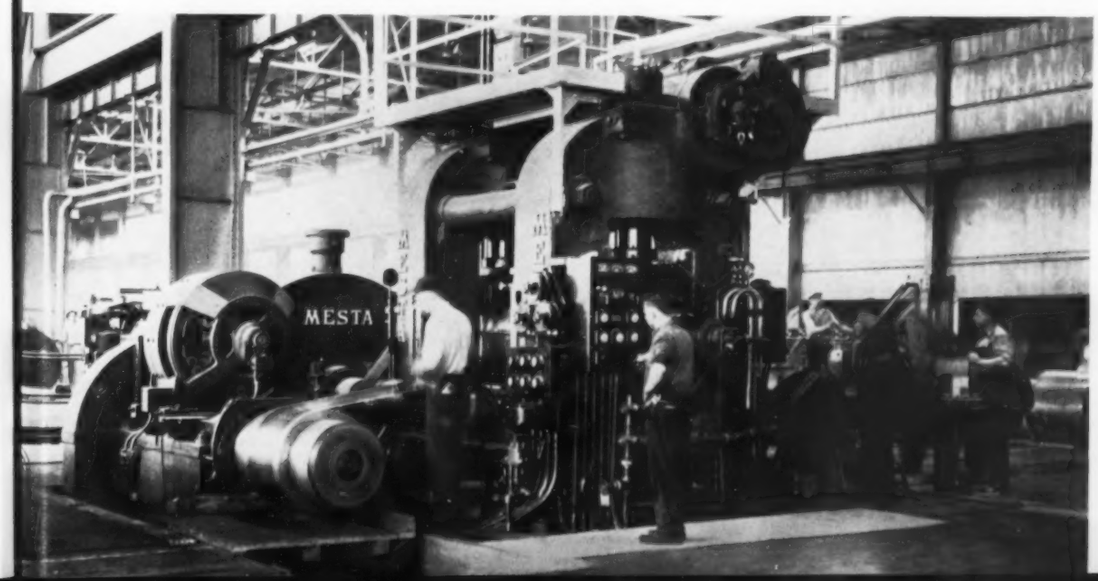


Fig. 9—Single two-high skin rolling mill

necks receiving their support from two heavy rotating rings, upon the internal circumference of which the necks are free to roll. Control of the gap between the one backing roll and the small middle roll is accomplished by moving the rings forward, or back, relative to the rolls which remain in their original vertical position. The bottom roll only is connected to the motor, the middle and top rolls being driven by friction from the bottom roll and the two rings, Fig. 11.

As yet, this type of mill has only been built in small sizes, of about 8″ roll face, but plans are under way for an increase in the face to about 16″.

THREE HIGH WATER MILL

During the year past considerable activity has been evidenced in the construction of three-high water mills as roughers for sheet and black plate mills.

Two sheet mill plants, of the manually operated type, are being rehabilitated by the addition of three-high water roughing mills, with automatic tables, screw down, etc., continuous pair and pack furnaces, automatic feeders and catchers on the finishing mills, mechanical doublers, automatic shears, etc.

One black plate mill is being similarly revamped, and one additional three-high roughing mill is being added at a fourth plant.

NILES ROLLING MILL CO.
NILES, OHIO

The work on this plant, which was completed in July of the present year, is typical of the type of rehabilitation possible for the old style, conventional sheet mill. The aim of the company has been to produce a plant for the production of sheet specialties, competitive both in quality and in production costs, with the mills of the continuous type.

This plant, built in 1919-20, was originally the Falcon Steel Co., and later the Falcon Plant of the Empire Steel Co., and comprised 10 stands of two high roughing, and 8 stands of two high finishing, hot black sheet mills, together with cold rolls, annealing and pickling equipment, and a hot galvanizing department, and other auxiliary equipment. The 18 hot mills have been replaced by one three high water roughing mill, and two two-high finishing mills, and one single two high combined roughing and finishing mill.

16″ sheet bar will be used, with the possibility later of using 24″ bars, or strip breakdowns. The bars will be heated in a continuous bar furnace, 90 feet long, and having a capacity of 12 tons per hour.

The new three high water roughing mill is equipped with rolls 32″ and 20″ x 56″ both the bottom and top rolls of which are driven. The bars will be broken down, in five passes to an average 16 gage at the rate of about four pairs per minute. On leaving the roughing mill the breakdowns are delivered to a conveyor which carries them to the charging ends of the two pack furnaces.

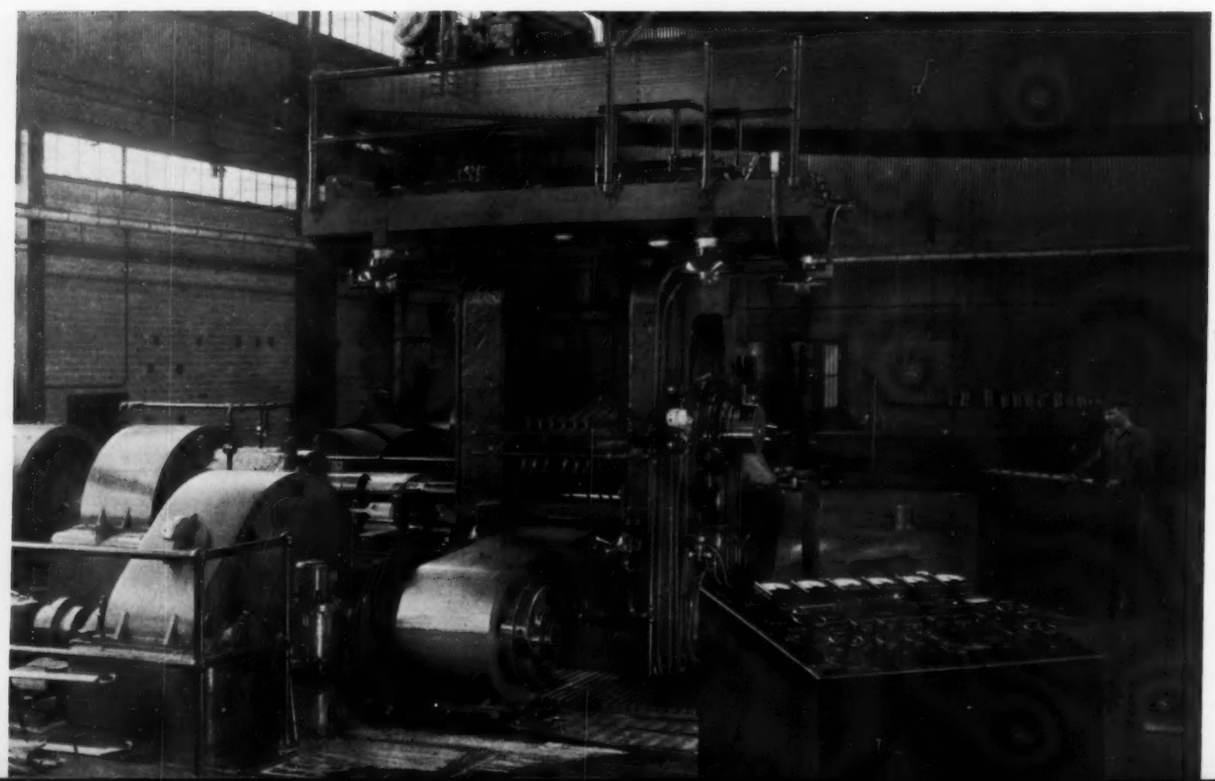
The pack furnaces are of the chain type, continuous, 80 feet in length and having a capacity of 10 tons per hour, each.

The finishing stands are two high and are equipped with full automatic feeder and catcher tables. A doubler is provided on the catchers side of each finishing mill, and the doubled packs are returned to the charging end of the pack furnaces by a conveyor starting beneath the floor in front of the doubler.

In addition to the three high rougher and the two two high finishers there is an additional two high stand manually operated, and served by one continuous pair and pack furnace, and which may be used for both roughing and finishing.

The three high roughing mill and the three two high finishing stands are all driven by a 1600 H.P. 240

Fig. 10—Four-high reversing cold strip mill



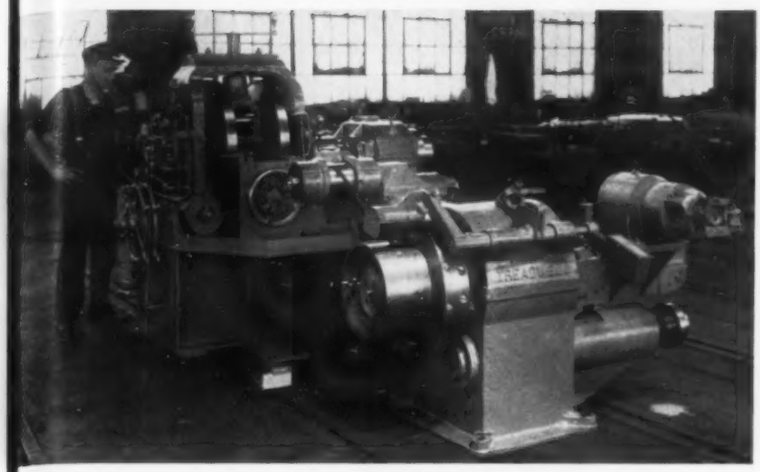


Fig. 11—Ring type cold strip mill

R.P.M. motor which originally drove the 18 stands of hand operated mills.

The finished packs are sheared to size on a Streine shear having a capacity of approximately 100 tons per turn in widths up to the capacity of the mill.

The pickling department has been largely reequipped, with a Mesta pickler and two lines of scrubbing and drying machines and three cold rolling mills, so arranged that sheets are pickled, scrubbed and dried, and cold rolled, in one uninterrupted operation.

Two gas fired normalizing furnaces are provided, and for box annealing there has been added a unit consisting of one radiant tube furnace cover, four bases and four inner covers. This is supplemented by the old style box annealing furnaces which formed part of the old plant.

There are also three trains of cold rolls, one of five and two of three stands each, which likewise formed part of the old layout. Each train is driven by a separate motor.

The annual capacity of the new layout, with four roll stands, is estimated at 60,000 tons as compared with 108,000 tons for the old layout, with 18 roll stands.

REPUBLIC STEEL CORPORATION
STARK SHEET MILL DIVISION
CANTON, OHIO

The Stark Sheet Mill Plant of the Republic Steel Corporation was originally built in 1900-01, and greatly enlarged in 1906-7. At the present time it consists of one jobbing plate mill, and 27 black sheet mills.

Under the modernization plans these mills will be replaced by two three-high water roughing mills, and four two high finishing mills, completely equipped with continuous pair and pack furnaces, automatic feeder and catcher tables, and auxiliary equipment.

Additional cranes, pickling equipment, pack shears, cleaning and cold rolling equipment will also be added.

The rated annual capacity of the mill, before remodeling, is given as 120,000 tons, annually, while the rated capacity of the new equipment will be approximately 100,000 tons.

REPUBLIC STEEL CORPORATION
TIN MILL
WARREN, OHIO

Announcement has recently been made that this plant is to be modernized by the replacement of the existing two high mills by two three-high water roughing mills, and four two high finishing mills, complete with continuous pair and pack furnaces, automatic feeder and catcher tables, doublers, etc., making it a fully mechanized unit.

SLEEVE TYPE BEARINGS

Roll neck bearings, of the sleeve type with oil film lubrication, are coming into more and more extended use.

For the rolling of Broad Strip, it is by this time well known that the Hot Broad Strip Mill, as well as the Cold Strip Mills, of the Youngstown Sheet & Tube Co., are completely equipped with sleeve bearings on the backing Rolls. Furthermore, two of the mills, now under construction, will be similarly equipped, both in the hot mill and in the cold mill, with bearings of this type.

NON-METALLIC BEARINGS

Roll neck bearings, of the non-metallic, phenolic resin type, are coming into increasing prominence, in practically all types of mills, from the two high reversing blooming mill, down to the wire rod mill, with the possible exception of the two-high hot sheet mill.

The three high water mills seem to offer a particularly advantageous field for this type of bearing, and most the recent installations have been equipped with them, on the top and bottom rolls, For the small working roll, the roller type seems to be preferred.

Developments now under way indicate the possibility of the use of bearings of this type with oil or grease lubrication, as well as with the water lubrication heretofore used.

ANNEALING

Perhaps the outstanding improvement, in recent years, in the annealing of sheets and strip, using fuel for heating, is to be found in the use of the radiant tube covers.

The method of annealing which has been in use from time immemorial has been to place the load of sheets to be annealed upon a heavy cast bottom plate, and cover with a correspondingly heavy cast cover, the weight of the bottom and cover about equalling the weight of the pile of sheets. The joint between the base and cover is then sealed with sand, or iron borings, and the whole pushed into a stationary furnace where it remained through a heating cycle of from 24 to 72 hours, after which it is removed from the furnace chamber and the cooling completed on the floor.

Under the new system the pile of sheets is made up on a stationary brick bottom, or foundation, and a

light sheet metal cover placed over it and sealed to exclude the air. Then a furnace cover, containing the heating elements in the shape of metal tubes, spaced along the sides, and raised to incandescence by burning gas inside of them, is placed over the charge and allowed to remain until the material to be annealed is raised to the desired temperature. The radiant tube cover is then lifted off and placed over a second charge of sheets without delay. The first charge is then permitted to cool, in place, access of air to the sheets being prevented by the inner cover. A controlled atmosphere is maintained surrounding the stock by means of an inert, or reducing gas, introduced within the inner cover.

A standard unit comprises: one radiant tube cover, three inner covers, and four bases.

ELECTRIC ANNEALING

The application of electricity as a means of supplying heat for annealing purposes has shown a consistent increase. Among the recent installations, and probably the most extensive to date, is the new mill of the Ford Motor Co., Dearborn, Mich. Two electrically heated units have been installed the one for the continuous annealing of strip, and the other for bright annealing, in coils.

The continuous furnace is 48″ inside width, and 227 ft. in length, and is equipped with automatic, sectional control of the heating elements. At the entry end of the furnace there is an uncoiler, leveler, and stitcher, and at the delivery end a dividing shear and recoiler, similar to those at the entry and delivery ends of a continuous pickling line, and serving the same purpose. The material after treatment in this furnace is suitable for most stamping and pressing operations, with the exception of deep drawing, and handling arrangements are being made in the press shop to enable coiled material to be used instead of short sheet lengths, as is now the case.

For deep drawing stock twenty-five electrically heated bell type furnaces have been installed. Each furnace is capable of holding two coils, each 48″ high, 52″ outside, and 30″ inside diameter, and having a combined weight of 32,000 lbs. The annealing cycle is about 45 hours, and the rated power consumption 230 K.W. each.

AUXILIARY EQUIPMENT

In the newer hot and cold broad strip mills there have been many refinements introduced that were non-existant in the older mills.

Among these may be noted particularly the use of electric instruments, such as Selsyns, for gaging the length and thickness of the rolled product, devices for indicating and recording the draft and roll neck pressures, and bearing temperatures.

We also have the Thyratron Tube for actuating sequential operations, such as the operation of the feeder and catcher tables, and screw down, on the automatic three high and two high sheet mills.

Great improvements have been made in the equipment for flattening, slitting and trimming, and cutting to length involving the use of the rotary flying shear in the case of cutting from coils. Similar advance has been made in shearing equipment for sheets in short lengths, as produced on the modern mechanized sheet mills.

Among the newer accessories to the sheet and tin mills may be mentioned the automatic classifier for cold rolled strip.

These machines cut, and classify the cut pieces into predetermined tolerances, E.G. into within plus or minus .0005″; over .0005″ heavy; and over .0005″ light. The classifier operates to deposit the light and heavy sheets into separate pockets underneath the table, while those within the tolerance pass to the end of the table, to a stagger piler, provided with an electric counter.

DIRECT ROLLING OF SHEETS

HAZLETT SYSTEM

The direct rolling of sheets from the molten metal is now an accomplished fact in the case of some non-ferrous metals and may later, if it has not already been accomplished, prove practicable in the case of steel.

Should this be successful, from the economic standpoint as well as from a scientific point of view, it will certainly rate recognition as the most radical innovation, in the working of steel since the invention of the Bessemer process.

ECONOMIC FEATURES

The broad statement is often made that we already have too many mills, of the Broad Strip type, in this country, and that further construction is unwarranted from the economic point of view.

If we are to weigh the value of such a statement it is necessary to analyze the statistics of finished rolled steel production of the country with a view of determining what proportion of the total constitutes the field of the Broad Strip Mill.

The characteristic product of the Broad Strip Mill is "FLAT ROLLED STEEL", and its field, in this product, is subject to certain limits of width and gage, and also, though in a minor degree, to characteristics of chemical analysis, physical properties, and finish.

DEFINITION

By "FLAT ROLLED STEEL" we mean: steel of substantially uniform thickness, and of comparatively high ratio of width to thickness, produced by rolling between plain cylindrical rolls.

An extension may be made to this definition to include non-slip floor plates, in the manufacture of which rolls having depressions milled in the surface, are used.

CLASSES OF FLAT ROLLED STEEL

Flat rolled steel comprises the following major groups of hot rolled products, arranged, more or less, in the order of their thickness.

PLATES—Sheared and Universal
SKELP
BLACK SHEETS

HOT ROLLED STRIP
BLACK PLATES
HOOPS COTTON TIES AND BANDS

FURTHER PROCESSING

The hot rolled product may be subjected to further processing of the character of:

Pickling, Oiling or Liming
Normalizing, Box Annealing, Deoxidizing, Blueing
Cold Rolling
Resquaring, Stretcher Leveling, Etc.

As a result of still further operations on the hot rolled products we have the following more highly finished products.

Cold Rolled (Full Finished) Sheets
Cold Rolled Strip

We also have the following coated products:

Galvanized Sheets
Tin and Terne Plate
Painted, Varnished or Lacquered Sheets.

PRODUCTION

FLAT ROLLED STEEL is the most important product of the rolling mill, from the standpoint of tonnage. During the past fifteen years it has constituted from 44% to 55% of the total finished rolled steel production of the country. During the past five years, particularly, it has shown a steady upward trend in relation to the total steel production.

POTENTIAL PRODUCT FOR STRIP MILL

The total production of flat rolled steel may be roughly divided into the following categories:

A—Potential product for the Hot Broad Strip Mill.

1—Finished to gage on the hot mill.

In this category we may take without serious error.
PLATES, Universal and sheared, 3/16" to 3/4" in thickness, 90" and under in width.
BLACK SHEETS, 16 gage and heavier, with minor exceptions.
17 and 18 gage in reduced widths.
SKELP, 16" wide and over.
HOT ROLLED STRIP, 16" wide and over.

2—Semi-finished product, for further reduction either as;
COILS, for further cold reduction and producing—
FULL FINISHED SHEETS, (in all widths and gages).
STRIP FOR TINNING (Cold Reduction tinplate).
CUT LENGTHS, Breakdowns for finishing hot on mills of the conventional type. and producing:
BLACK SHEETS, 17 gage and lighter.
BLACK PLATE FOR TINNING.

B—At present unsuitable for the Hot Broad Strip Mill.
PLATES, Universal and sheared, over 90" in width and/or over 3/4" in thickness.
SKELP, under 16" wide.
HOT ROLLED STRIP, under 16" wide.
Much of the tonnage in the two latter items might readily be supplied by hot rolling in multiple widths and slitting to size.
BLACK SHEETS
Certain specialties which on account of chemical analysis, physical properties, finish or quantity are not adapted to a continuous method or rolling.
HOOP, COTTON TIES AND BANDS.

Classifying the total rolled steel production in accordance with the above criterion we arrive at a figure of approximately 42% of the total finished rolled steel production of the country as included in the class of potential product for the Hot Broad Strip Mill.

POTENTIAL MARKET FOR HOT STRIP MILL

Based upon an estimated production for 1935 of 26,000,000 tons of finished rolled steel products, and taking 42% of the total as constituting the field of the Hot Broad Strip Mill, and assuming that all the mills would run at an average capacity of 425,000 tons annually, per mill, it would require 25 such mills to produce the total potential tonnage as calculated above.

FIELD OF COMPETITION

The foregoing discussion relates to the field of competition of the broad strip mill. Competing in this same field there is a large existing capacity, in older, higher cost, and generally less efficient plant, the total capacity of which is amply sufficient to meet the demand of a year comparable in tonnage with 1935.

The existing capacity competitive in different ranges of the field of the broad strip mill, comprises the following:

Universal and sheared plate mills
Jobbing plate mills
Black sheet mills
Black plate mills, (tin mills)
Skelp mills, 16" and wider
Hot strip mills, 16" and wider
Sheet bar mills.

It is unnecessary to state that under a condition of untrammelled price competition the broad strip mill would be able to take such business within their range as they desired, leaving only to the older mills, orders that were small in quantity, or otherwise, on account of special analysis, physical properties, or finish, were either unadaptable to, or unprofitable for, the broad strip mill.

The back log of the old style mills would be the approximately 15% of the total finished steel production taken as unsuitable for the broad strip mill, and this would be increased, as the total production rose, by

such tonnage as the broad strip mills were unable to find place for on their rolling schedule.

Much has been said about the tremendous cost of the mills of the Broad Strip type. That the cost is high is true, but, in my opinion, no other combination of mills, two, three or more, costing an equal amount, could hope to tap anywhere near the same potential market that is open to the Broad Strip Mill.

At this time, a year ago, the great problem engaging the attention of the full finished sheet producers, was the production of full finished sheets, of auto-body quality, in widths up to 100″.

Some further approach has been made to the solution during the past year, and at least three producers are now equipped to furnish cold rolled sheets from 72″ to 90″ wide, by cross rolling a narrower strip. Furthermore at least one producer is in a position to cold roll strip in coils up to 84″ in width. and when the 100″ mill of the Carnegie-Illinois Steel Corp. at Homestead goes into operation, presumably in 1936, it will be possible to obtain hot rolled strip, in coils, to a maximum width of 90″ or over, and cold rolling mills will undoubtedly be built to cold roll this product, in long coils, to auto-body gages.

Whether this will meet the demand, or whether still wider sheets will be called for, remains to be seen.

CONCLUSION

In my paper, last year, I stated that "to use a military term, the year past had been occupied in a consolidation of the positions gained in the several preceding years."

To carry out the simile we may say that the year 1935 represents "a renewed offensive on both fronts." The extent of this may be gaged by the amount of added capacity which, both in hot and in cold rolling, represents an amount approximately equal to, and perhaps greater than, the entire capacity previously installed.

The new mill of the Carnegie-Illinois Steel Corporation, Homestead Works, announcement of which has recently been made, will be of a character somewhat different from any of the mills recently built, and will present some points of similarity with the original Broad Strip Mill, at Butler.

100″ CONTINUOUS PLATE MILL
HOMESTEAD WORKS
CARNEGIE-ILLINOIS STEEL CO.
MUNHALL, PA.

The new mill will be a 100″ semi-continuous, electric driven, sheared plate mill, located between the present 110″ (Liberty) plate mill, and the Lake Erie tracks, West Homestead, Pa., covering an area of 1800 ft. by approximately 300 ft., over all, with a floor area under roof of 404 210 sq. ft., approximately 9¼ acres.

The mill will consist of the following:

Four continuous type re-heating furnaces
One 36″ x 100″, two-high, non-reversing scale breaker stand
One 42″–52″ x 120″, four-high spreading stand
One slab squeezer
One 36″–54″ x 100″ four-high reversing roughing stand with
One vertical edging stand
Four 27″–54″ x 100″ four-high, continuous finishing stands
Shears and normalizing equipment

The average slab used by the mill will be 54″ x 6″ x 90″ and the finished product will measure from 20″ to 90″ in width, by —″ ro ¾″ inclusive, in gage.

The product will range from standard carbon steel to high tensile steels, such as U. S. Steel Corporation, Cor-Ten, Man-Ten and Sil-Ten.

The rated capacity of the mill is 728,900 tons per year.

JONES & LAUGHLIN STEEL CORPORATION, PITTSBURGH, PA.

Since the foregoing paper was written, announcement was made by the Jones & Laughlin Steel Corp'n., of a $40,000,000 plan for new improvements and expansion, included in which is a $25,000,000 strip and sheet mill to be erected in the Pittsburgh Works. This will mark the entrance of the Jones & Laughlin Steel Corp'n., on a large scale, into this important line of consumer products.

Additional employment will occur in the new mills as well as in the increased production of materials for them in the existing plants of the Corporation, in the manufacture of coke, pig iron, and steel ingots, as well as employment of thousands in the construction of the new mills.

The proposed new mills heralds the long anticipated entrance of Jones & Laughlin into the production of strip and sheets. The decision to engage in this branch of steel manufacture was arrived at, after a comprehensive study was made, over an extended period, of all the major steel products, with the conclusion that strip and sheets best met the need of the Corporation requirements for increased consumer goods.

Included in the purposes of the $40,000,000 financing, in addition to the $25,000,000 for the new strip and sheet mill, are provisions for working capital required for reimbursement of expenditures already made, and yet to be made, for the $5,000,000 electrically driven 44″ Blooming Mill in the Pittsburgh Works, also $1,500,000 for additions and improvements to the four-high cold reducing mill in the Aliquippa Works, and $3,000,000 for capital expenditures already made and shortly to be made, and for other working capital requirements.

This action on the part of the Jones & Laughlin Steel Corp'n. means that the nine largest steel producers, or those having more than 1,000,000 tons annual ingot capacity, will each have one or more mills of the Broad Strip type, a total of 18 mills, the remaining four being owned by smaller companies.

IRON AND STEEL ENGINEER INDEX FOR 1935

Herewith is presented the index of all authors, papers, and discussions published in the IRON AND STEEL ENGINEER for the year 1935.

A

ANGEL, H. H.—*Crane Control*, February, 1935, 90.

B

BADLAM, STEPHEN—*Developments in Flat Steel Rolling*, December, 1935, 40.
BALLENGER, W. M.—*Automatic Preset Screwdown Control*, July, 1935, 434.
BATEMAN, W. H. AND E. A. JAMISON—*Propane and Butane as Industrial Fuels*—April, 1935, 209.
BAUMGARTEN, G. W.—*Maintenance Problems on Old Cranes*, February, 1935, 102.
BAYLE, R. M.—*Automatic Screwdown Control*, July, 1935, 425.
BEAMAN, J. FRANK—*Future of Steel Industry*, September, 1935, 30.
BECHTEL, T. B.—*Control of Scale Formation in Heating Steel*, January, 1935, 26.
BECHTEL, T. B.—*Controlled Atmosphere Applications to Heating of Steel*, November, 1935, 1.
BLYTHE, W. E.—*High Temperature Conveyors, A Novel Type for Heating Furnaces*, October, 1935, 16.
BOHN, D. I.—*Recent Developments in the Welding of Aluminum Alloys*, January, 1935, 16.
BOWLES, H. J.—*Progress of Electric Welding in the Steel Industry*, May, 1935, 285.
BOYNTON, A. J.—*Use of Automatic Control on Metallurgical Furnaces*, March, 1935, 159.
BOWER, R. S.—*The Developments in the Design and Operation of Open Hearth Furnaces*, July, 1935, 413.
BURD, F. J.—*Screwdown Control*, July, 1935, 432.
BURG, J. A.—*Track Wheels—Rails—Bumpers*, February, 1935, 93.
BURR, W. H.—*Steel Mill Developments Report of A. I. & S. E. E. Committee*, September, 1935, 34.
BUSSEY, H. E.—*Lightning and Lightning Protection*, May, 1935, 301.

C

CALDWELL, G. A. AND S. F. HENDERSON—*Roll Table Equipment for Modern Wide Strip Mills*, December, 1935, 29.
CALDWELL, G. A.—*Steel Mill Applications of General Purpose Motors*, May, 1935, 294.
CARROLL, G. R.—*Crane Rails*, February, 1935, 94.
CONWAY, MARTIN J.,—*Open Hearth Control*, September, 1935, 31.

D

DANIELS, F. C. T.—*Cast Roll Progress in 1934*, January, 1935, 25.
DEROSAY, K. E. AND J. H. G. MCCONECHY—*The Generation of Power in Industry by Diesel Engines Using Heavy Fuel Oils*, May, 1935, 297.
DUNCAN, A. W.—*General Maintenance*, February, 1935, 98.
DUNKAK, E. B.—*Theory and Practice of Immersion Heating with Gaseous Fuels*, March, 1935, 167.

E

EGAN, F. D. —*Maintenance Crane Bridges and Trolleys*, February. 1935, 92.
EMMERLING, KARL—*Natural Gas in Steel Plants*, June, 1935, 337.

F

FARRINGTON, J.—*Bearings, Lubrication, Gears and Pinions, Shafting*, February, 1935, 95.
FIRST, GORDON W.—*Automatic Sheet Measuring Device*, May, 1935, 292.
FISHER, A. J.—*Automatic Control and Use of Fuels in Steel Mill Furnaces*, March, 1935, 149.
FRAUENTHAL, A. H.—*Influence of Roll Neck Deflection on Life of Anti-Friction Bearings*, June, 1935, 356.
FOLEY, EDWARD H., JR.—*Steel in Federal Projects, Billion Dollars for Steel and Allied Products*, October, 1935, 31.

G

GALE, R. F.—*Crane Safety*, February, 1935, 87.
GIRDLER, T. M.—*Economic Importance of A. I. & S. E. E. Convention and Iron and Steel Exposition*, September, 1935, 19.
GREGORY, C. V. AND F. E. HARRELL—*Individual Motor Drives for Run Out Tables and Coilers*, August, 1935, 1.

H

HANSSON, EDWARD AND B. VAN NESS, JR.—*Lightning Protection for Power Systems*, February, 1935, 73.
HARMON, G. N.—*Transportation*, January, 1935, 22.
HARRELL, F. E. AND C. V. GREGORY—*Individual Motor Drives for Run Out Tables and Coilers*, August, 1935, 1.
HARRY, R. J.—*Electric Overhead Traveling Cranes*, February, 1935, 84.
HENDERSON, S. F. AND G. A. CALDWELL—*Roll Table Equipment for Modern Wide Strip Mills*, December, 1935, 29.
HILDEBRAND, L. E. AND W. B. SNYDER—*Individual Motor Drives for Runout Tables and Coiler Rolls*, December, 1935, 16.
HITCHCOCK, J. H. —*A Self-Aligning Device for the Work Rolls of Four High Mills*, June, 1935, 354.—*Oil Flooded Bearings, Uses in Steel Rolling Mills*, November, 1935, 14.
HORNE, H. F.—*Laminated Bearings Their Use in Different Types of Rolling Mills*, November, 1935, 12.
HUGHES, GROVER A.—*Welding Developments During the Year 1934-1935*, September, 1935, 65.
HUNT, C. H.—*The Weirton Steel Company, Its History and Development*, September, 1935, 33.

J

JAMISON, E. A. AND W. H. BATEMAN—*Propane and Butane as Industrial Fuels*—April 1935, 209.

K

KEEL, J. C.—*Crane Wheels*, February, 1935, 87.
KEENER, S. F.—*Field Drawing of Roll Neck Bearings*, June, 1935, 345.
KLEIN, C. J.—*Roll Neck Bearings*, April, 1935, 238.
KULAS, E. J.—*Economic Importance of A.I. & S.E.E. Convention and Iron and Steel Exposition*, September, 1935, 18.

L

LITVIN, P. L.—*The Trend of Electrification in the Steel Plants of the U.S.S.R.*, May, 1935, 290.
LYNN, C.—*Selection of Equipment for DC Power In Rolling Mills*, August, 1935, 17.

Mc

MCCONECHY, J. H. G. AND K. E. DEROSAY—*The Generation of Power in Industry by Diesel Engines Using Heavy Fuel Oils*, May, 1935, 297.
MCDERMOTT, G. R.—*Soaking Pits*, June, 1935, 369.
MCELRAY, T. B.—*General Maintenance*, February, 1935, 97.
MCGRANAHAN, C. L.—*Flat Rolling of Steel, Factors Influencing Its Production*—December, 1935, 1.
MCKEE, ARTHUR G.—*The Development of the Modern Blast Furnace*, January, 1935, 1.

M

MACGILL, K. T.—*Composition Bearings—Recent Progress in their Use*, November, 1935, 9.
MELLON, J. J.—*Electric Controllers for Three-High Sheet Roughing Mill Screwdowns*, July, 1935, 430.
MERRICK, F. A.—*A Statement for 1935*, January, 1935, 20.
MOELLER, C. H.—*Fork Lift Electric Trucks in Steel Mills*, January, 1935, 23.
MOORE, R. W. AND E. S. REYNOLDS—*Selection of Lubricants for Cold Rolling of Strip Steel*, December, 1935, 24.

P

PALMGREN, G.—*Roll Neck Bearings*, June 1935, 347.
PETTY, D. M.—*Importance of Replacement of Obsolete Equipment in Steel Mills*, August, 1935, 10.
PFEFFER, G. C.—*Crane Motors and Gears*, February, 1935, 91.
PURNELL, FRANK—*What the A.I. & S.E.E. Spring Conference Means to the Steel Industry*, April, 1935, 227.

R

REYNOLDS, E. S. AND R. W. MOORE—*Selection of Lubricants for Cold Rolling of Strip Steel*, December, 1935, 24.
RICHARDSON, H. M.—*Composition Bearings For Roll Necks and Other Purposes*, November, 1935, 5.
ROBB, H. D.—*Maintenance of Roll Neck Bearings*, June, 1935, 342.
ROSENQUIST, B. A. E.—*Bridges and Trolleys*, February, 1935, 102.

S

SAWTELLE, E. S.—*Crane Wheels*, February, 1935, 92.
SHELDON, HARRY E.,—*An Era of Industrial Research—A Challenge to the Society*, September, 1935, 28.
SNYDER, W. B.—*General Purpose Motors for Steel Mill Applications*, April, 1935, 214.
SNYDER, W. B. AND L. E. HILDEBRAND—*Individual Motor Drives for Runout Tables and Coiler Rolls*, December, 1935, 16.
STANDING, A. J.—*Anti-Friction Bearings for Cranes*, February, 1935, 88.

T

TINNON, J. B.—*Thermit Welding*, February, 1935, 104.

U

UPTON, C. W.—*General Maintenance*, February, 1935, 96.

V

VAN CAMPEN, J. H.—*Strip Steel*, April, 1935, 239.
VAN CAMPEN, J. H.—*Wide Strip Mills*, June, 1935, 367.
VAN NESS, B. JR., AND EDWARD HANSSON—*Lightning Protection for Power Systems*, February, 1935, 73.

W

WALSH, E. I.—*New Fork Truck Speeds Operation in Tin Plate Mills*, January, 1935, 24.
WEAN, R. J.—*Flat Rolled Steel Products, Processing for Automotive Industry*, December, 1935, 12.
WECKSTEIN, S. M.—*Roller Bearing Applications, In Continuous Strip Mills and Rod Mills*, October, 1935, 23.
WEIR, E. T.—*Industrial Relations, The Association's Influence*, September, 1935, 14.

Y

YORKEY, W. R.—*Crane Control*, February, 1935, 91.
YOUNG, ARTHUR, H.—*Industrial Relations, The Human Element in Industry*, October, 1935, 11.

▲

LIST OF SUBJECTS

A

A.I. & S.E.E. Committee—Steel Mill Developments Report of—By W. H. BURR, September, 1935, 34.
A. I. & S. E. E. Convention and Iron and Steel Exposition—Economic Importance of—By E. J. KULAS AND T. M. GIRDLER, September, 1935, 18.
Aligning Device for the Work Rolls of Four High Mills—A Self—By J. H. HITCHCOCK, June, 1935, 354.
Allied Industries During the Year 1934—Electric Motors over 300 Horsepower Applied to Main Roll Drives in the Iron and Steel and—January, 1935, 33.
Allied Products—Steel in Federal Projects, Billion Dollars for Steel and—By EDWARD H. FOLEY, October, 1935, 31.
Alloys—Recent Developments in the Welding of Aluminum—By D. I. BOHN, January, 1935, 16.
Aluminum Alloys—Recent Developments in the Welding of—By D. I. BOHN, January, 1935, 16.
Anti-Friction Bearings for Cranes—By A. J. STANDING, February, 1935, 88.
Anti-Friction Bearings—Influence of Roll Neck Deflection on Life of—By A. H. FRAUENTHAL, June, 1935, 356.
Anti-Friction Bearings to Roll Necks of Steel Rolling Mills in Service—Tabulation of Applications of—September, 1935, 75.
Applications—General Purpose Motors for Steel Mill—By W. B. SNYDER, April, 1935, 214.
Applications, In Continuous Strip Mills and Rod Mills, Roller Bearing—By S. M. WECKSTEIN, October, 1935, 23.
Applications of Anti-Friction Bearings to Roll Necks of Steel Rolling Mills in Service—Tabulation of—September, 1935, 75.
Applications of General Purpose Motors—Steel Mill—By G. A. CALDWELL, May, 1935, 294.
Applications to Heating of Steel—Controlled Atmosphere—By T. B. BECHTEL, November, 1935, 1.
Atmosphere, Applications to Heating of Steel—Controlled—By T. B. BECHTEL, November, 1935, 1.
Automatic Control and Use of Fuels in Steel Mill Furnaces—By A. J. FISHER, March, 1935, 149.
Automatic Control on Metallurgical Furnaces, Use of—By A. J. BOYNTON, March, 1935, 159.
Automatic Sheet Measuring Device—By GORDON W. FIRST, May, 1935, 292.
Automatic Preset Screwdown Control—By W. M. BALLENGER, July, 1935, 434.
Automatic Screwdown Control—By R. M. BAYLE, July, 1935, 425.
Automotive Industry, Flat Rolled Steel Products—Processing for—By R. J. WEAN, December, 1935, 12.

B

Bearing Applications, In Continuous Strip Mills and Rod Mills—Roller—By S. M. WECKSTEIN, October, 1935, 23.
Bearings—Field Drawing of Roll Neck—By S. F. KEENER, June, 1935, 345.
Bearings for Cranes—Anti-Friction—By A. J. STANDING, February, 1935, 88.
Bearings—For Roll Necks and Other Purposes, Composition—By H. M. RICHARDSON, November, 1935, 5.
Bearings—Influence of Roll Neck Deflection on Life of Anti-Friction—By A. H. FRAUENTHAL, June, 1935, 356.
Bearings—Maintenance of Roll Neck—By H. D. ROBB, June, 1935, 342.
Bearings, Lubrication, Gears and Pinions, Shafting—By J. FARRINGTON, February, 1935, 95.
Bearings—Recent Progress in their Use—Composition—By K. T. MACGILL, November, 1935, 9.
Bearings—Roll Neck—By C. J. KLEIN, April, 1935, 238.
Bearings—Roll Neck—By G. PALMGREN, June, 1935, 347.
Bearings, Their Use in Different Types of Rolling Mills—Laminated—By H. F. HORNE, November, 1935, 12.
Bearings to Roll Necks of Steel Rolling Mills in Service—Tabulation of Anti-Friction—September, 1935, 75.
Bearings, Uses in Steel Rolling Mills—Oil Flooded—By J. H. HITCHCOCK, November, 1935, 14.
Billion Dollars for Steel and Allied Products, Steel in Federal Projects—By EDWARD H. FOLEY, October, 1935, 31.
Blast Furnace—The Development of the Modern—By ARTHUR G. MCKEE, January, 1935, 1.
Bridges and Trolleys—By B. A. E. ROSENQUIST, February, 1935, 102.
Bridges and Trolleys, Maintenance Crane—By F. D. EGAN, February, 1935, 92.
Bumpers, Track-Wheels-Rails—By J. A. BURG, February, 1935, 93.
Butane as Industrial Fuels, Propane and—By E. A. JAMISON AND W. H. BATEMAN, April, 1935, 209.

C

Cast Roll Progress in 1934—By F. C. T. DANIELS, January, 1935, 25
Challenge to the Society—An Era of Industrial Research, A—By HARRY E. SHELDON, September, 1935, 28.
Coiler Rolls—Individual Motor Drives for Runout Tables and—By W. B. SNYDER AND L. E. HILDEBRAND, December, 1935, 16.
Coilers—Individual Motor Drives for Run Out Tables and—By F. E. HARRELL, AND C. V. GREGORY, August, 1935, 1.
Cold Rolling of Strip Steel—Selection of Lubricants for—By R. W. MOORE AND E. S. REYNOLDS, December, 1935, 24.
Committee—Steel Mill Developments Report of A.I. & S.E.E.—By W. H. BURR, September, 1935, 34.
Composition Bearings, For Roll Necks and Other Purposes—By H. M. RICHARDSON, November, 1935, 5.
Composition Bearings, Recent Progress in their use—By K. T. MACGILL November, 1935, 9.
Continuous Strip Mills and Rod Mills, Roller Bearing Applications in—By S. M. WECKSTEIN, October, 1935, 23.
Control—Automatic Preset Screwdown—By W. M. BALLENGER, July, 1935, 434.
Control—Automatic Screwdown—By R. M. BAYLE, July, 1935, 425.
Control and Use of Fuels in Steel Mill Furnaces, Automatic—By A. J. FISHER, March, 1935, 149.
Control—Crane—By H. H. ANGEL, February, 1935, 90.
Control—Crane—By W. R. YORKEY, February, 1935, 91.
Control of Scale Formation in Heating Steel—By T. B. BECHTEL, January, 1935, 26.
Control on Metallurgical Furnaces—Use of Automatic—By A. J. BOYNTON, March, 1935, 159.
Control—Open Hearth—By M. J. CONWAY, September, 1935, 31.

Control—Screwdown—By F. J. Burd, July, 1935, 432.
Controlled Atmosphere, Applications to Heating of Steel—By T. B. Bechtel, November, 1935, 1.
Controllers for Three-High Sheet Roughing Mill Screwdowns—Electric—By J. J. Mellon, July, 1935, 430.
Convention and Iron and Steel Exposition—Economic Importance of A.I. & S.E.E.—By E. J. Kulas and T. M. Girdler, September, 1935, 18.
Conveyors, High Temperature, A Novel Type for Heating Furnaces—By W. E. Blythe, October, 1935, 16.
Crane Bridges and Trolleys, Maintenance—By F. D. Egan, February, 1935, 92.
Crane Control—By H. H. Angel, February, 1935, 90.
Crane Control—By W. R. Yorkey, February, 1935, 91.
Crane Motors and Gears—By G. C. Pfeffer, February, 1935, 91.
Crane Rails—By G. R. Carroll, February, 1935, 94.
Crane Safety—By R. F. Gale, February, 1935, 87.
Crane Statistics 1934—Electrically Operated—January, 1935, 28.
Crane Wheels—By E. S. Sawtelle, February, 1935, 92.
Crane Wheels—By J. C. Keel, February, 1935, 87.
Cranes—Anti-Friction Bearings for—By A. J. Standing, February, 1935, 89.
Cranes—Electric Overhead Traveling—By R. J. Harry, February, 1935, 84.
Cranes—Maintenance Problems on Old—By G. W. Baumgarten, February, 1935, 102.

D

DC Power in Rolling Mills—Selection of Equipment for—By C. Lynn, August, 1935, 17.
Deflection on Life of Anti-Friction Bearings—Influence of Roll Neck—By A. H. Frauenthal, June, 1935, 356.
Design and Operation of Open Hearth Furnaces—The Developments in—By R. S. Bower, July, 1935, 413.
Development of the Modern Blast Furnace—The—By Arthur G. McKee, January, 1935, 1.
Developments During the Year 1934-1935—Welding—By Grover A. Hughes, September, 1935, 65.
Developments in the Design and Operation of Open Hearth Furnaces—The—By R. S. Bower, July, 1935, 413.
Developments in the Iron and Steel Industry During the Year 1934—January, 1935, 29.
Developments in the Welding of Aluminum Alloys—Recent—By D. I. Bohn, January, 1935, 16.
Developments Report of A.I. & S.E.E. Committee—Steel Mill—By W. H. Burr, September, 1935, 34.
Device for the Work Rolls of Four High Mills—A Self-Aligning—By J. H. Hitchcock, June, 1935, 354.
Diesel Engines Using Heavy Fuel Oils—The Generation of Power in Industry by—By J. H. G. McConechy and K. E. DeRosay, May, 1935, 297.
Different Types of Rolling Mills—Laminated Bearings, Their Use in—By H. F. Horne, November, 1935, 12.
Discussion: Automatic Control and Use of Fuels in Steel Mill Furnaces—By P. C. Reichard, M. J. Conway, and W. Goehring, March, 1935, 156.
Discussion: Composition Bearings for Roll Necks and Other Purposes, Composition Bearings, Recent Progress in their Use, Laminated Bearings, Their Use in Different Types of Rolling Mills—By C. C. Pecu, F. L. Estep and L. F. Coffin, November, 1935, 16.
Discussion: Cranes—By H. W. Ball, Leroy Brooks, B. R. Shover, J. L. Young, W. E. Miller, G. R. Carroll, A. W. McAuly, R. J. Harry, J. Farrington, M. J. Conway, W. A. Marshall, February, 1935, 99.
Discussion: Development of the Modern Blast Furnace—The—By G. R. McDermott, A. G. McKee, J. C. Hopkins, B. M. Stubblefield and L. E. Riddle, January, 1935, 13.
Discussion: Developments in the Design and Operation of Open Hearth Furnaces—The—By T. J. McLoughlin, F. E. Leahy, R. S. Bower, A. J. Boynton, E. A. Hawk, M. J. Conway, W. C. Buell, Jr. and F. C. Swartz—July, 1935, 423.
Discussion: Flat Rolled Steel Products, Processing for Automotive Industry—By C. L. McGranahan, F. E. Flynn and R. J. Wean, December, 1935, 15.
Discussion: Flat Rolling of Steel—Factors Influencing Its Production—By F. E. Flynn, R. W. Graham, C. L. McGranahan, A. S. Hellstrom, R. J. Wean, J. H. Van Campen, H. D. Esterly and J. Farrington, December, 1935, 8.
Discussion: Lightning Protection for Power Systems—By W. H. Burr, F. A. Allner, J. C. Reed, L. H. Fister, B. Van Ness, Jr., A. J. Standing. E. Hansson, H. H. Angel, E. L. Anderson and H. D. Esterly, February, 1935, 81.
Discussion: Maintenance of Roll Neck Bearings—By R. S. Shoemaker, J. H. VanCampen, H. D. Robb, S. M. Weckstein, H. H. Talbot, J. H. Vohr, A. E. Miller, F. J. Thomas, A. W. Steed, J. L. Young, A. H. Frauenthal, G. Palmgren, J. H. Hitchcock, J. L. Miller, and G. S. Warren, June, 1935, 360.
Discussion: Natural Gas in Steel Plants—By F. B. Jones, H. V. Flagg, A. J. Boynton, J. L. Miller and K. Emmerling, June, 1935, 341.
Discussion: Oil Flooded Bearings, Uses in Steel Rolling Mills—By C. C. Pecu, J. H. Hitchcock, M. Stone, Myles Morgan and H. M. Richardson, November, 1935, 16.
Discussion: Propane and Butane as Industrial Fuels—By G. T. Hollett, W. H. Bateman, H. V. Flagg, C. A. Kral and C. T. Konecny, April, 1935, 213.
Discussion: Selection of Equipment for DC Power in Rolling Mills—By H. A. Winne, and G. E. Stoltz, August, 1935, 20.
Discussion: Soaking Pits—By M. J. Conway, G. D. Mantle, M. J. Bradley, L. F. Coffin, and T. J. Ess, June 1935, 371.
Discussion: Theory and Practice of Immersion Heating with Gaseous Fuels—By G. M. Coughlin, E. B. Dunkak, M. J. Conway, J. H. Strassberger, H. V. Flagg, March, 1935, 171.
Discussion: Thermit Welding—By C. Simera, L. F. Coffin, J. B. Tinnon, J. F. Gillespie, and C. O. Franklin, February, 1935, 108.
Discussion: Use of Automatic Control on Metallurgical Furnaces—By M. J. Bradley, G. M. Coughlin, M. J. Conway, E. W. Trexler and G. Fox—March, 1935, 165.
Drawing of Roll Neck Bearings—Field—By S. F. Keener, June, 1935, 345.
Drives for Runout Tables and Coiler Rolls—Individual Motor—By W. B. Snyder and L. E. Hildebrand, December, 1935, 16.
Drives for Runout Tables and Coilers—Individual Motor—By F. E. Harrell and C. V. Gregory, August, 1935, 1.
Drives in the Iron and Steel and Allied Industries, During the Year 1934—Electric Motors over 300 Horsepower Applied to Main Roll—January, 1935, 33.
During the year 1934—Developments in the Iron and Steel Industry—January, 1935, 29.
During the Year 1934—Electric Motors over 300 Horsepower Applied to Main Roll Drives in the Iron and Steel and Allied Industries—January, 1935, 33.
During the Year 1934-1935—Welding Developments—By Grover A. Hughes, September, 1935, 65.

E

Economic Importance of A. I. & S. E. E. Convention and Iron and Steel Exposition—By E. J. Kulas and T. M. Girdler, September, 1935, 18.
Electric Controllers for Three-High Sheet Roughing Mill Screwdowns—By J. J. Mellon, July, 1935, 430.
Electric Motors over 300 Horsepower Applied to Main Roll Drives in the Iron and Steel and Allied Industries, During the Year 1934,—January, 1935, 33.
Electric Overhead Traveling Cranes—By R. J. Harry, February, 1935, 84.
Electric Trucks in Steel Mills—Fork Lift—By C. H. Moeller, January, 1935, 23.
Electric Welding in the Steel Industry—Progress of—By H. J. Bowles, May, 1935, 285.
Electrically Operated Crane Statistics—1934—January, 1935, 28.
Electrification in the Steel Plants of the U.S.S.R.—The Trend of—By P. L. Litvin, May, 1935, 290.
Element in Industry—Industrial Relations, The Human—By Arthur H. Young, October, 1935, 11.
Engineer Index for 1934—Iron and Steel—January, 1935, 34.
Engines Using Heavy Fuel Oils—The Generation of Power in Industry by Diesel—By J. H. G. McConechy and K. E. DeRosay, May, 1935, 297.
Equipment for DC Power in Rolling Mills—Selection of—By C. Lynn, August, 1935, 17.
Equipment for Modern Wide Strip Mills—Roll Table—By G. A. Caldwell and S. F. Henderson, December, 1935, 29.
Equipment in Steel Mills—Importance of Replacement of Obsolete—By D. M. Petty, August, 1935, 10.
Era of Industrial Research—A Challenge to the Society—An—By Harry E. Sheldon, September, 1935, 28.
Exposition—Economic Importance of A.I. & S.E.E. Convention and Iron and Steel—By E. J. Kulas and T. M. Girdler, September, 1935, 18.

F

Factors Influencing Its Production—Flat Rolling of Steel—By C. L. McGranahan, December, 1935, 1.
Federal Projects, Billion Dollars for Steel and Allied Products, Steel in—By Edward H. Foley, October, 1935, 31.
Field Drawing of Roll Neck Bearings—By S. F. Keener, June, 1935, 345.
Flat Rolled Steel Products, Processing for Automotive Industry—By R. J. Wean, December, 1935, 12.
Flat Rolling of Steel—Factors Influencing Its Production—By C. L. McGranahan, December, 1935, 1.
Flooded Bearings, Uses in Steel Rolling Mills—Oil—By J. H. Hitchcock, November, 1935, 14.

F—(Continued)

Fork Lift Electric Trucks in Steel Mills—By C. H. MOELLER, January 1935, 23.
Fork Truck Speeds Operation in Tin Plate Mills—New—By E. I. WALSH, January, 1935, 24.
Formation in Heating Steel—Control of Scale—By T. B. BECHTEL, January, 1935, 26.
Four High Mills—A Self-Aligning Device for the Work Rolls of—By J. H. HITCHCOCK, June, 1935, 354.
Fuel Oils—The Generation of Power in Industry by Diesel Engines Using Heavy—By J. H. G. MCCONECHY AND K. E. DEROSAY, May, 1935, 297.
Fuels, Propane and Butane as Industrial—By E. A. JAMISON AND W. H. BATEMAN, April, 1935, 209.
Fuels in Steel Mill Furnaces—Automatic Control and Use of—By A. J. FISHER, March, 1935, 149.
Fuels—Theory and Practice of Immersion Heating with Gaseous—By E. B. DUNKAK, March, 1935, 167.
Furnace—The Development of the Modern Blast—By ARTHUR G. MCKEE, January, 1935, 1.
Furnaces—Automatic Control and Use of Fuels in Steel Mill—By A. J. FISHER, March, 1935, 149.
Furnaces, High Temperature Conveyors, A Novel Type for Heating—By W. E. BLYTHE, October, 1935, 16.
Furnaces—The Developments in the Design and Operation of Open Hearth—By R. S. BOWER, July, 1935, 413.
Furnaces—Use of Automatic Control on Metallurgical—By A. J. BOYNTON, March, 1935, 159.
Future of Steel Industry—By J. FRANK BEAMAN, September, 1935, 30.

G

Gas in Steel Plants—Natural—By KARL EMMERLING, June, 1935, 337.
Gaseous Fuels—Theory and Practice of Immersion Heating with—By E. B. DUNKAK, March, 1935, 167.
Gears and Pinions, Shafting, Bearings, Lubrication—By J. FARRINGTON, February, 1935, 95.
Gears—Crane Motors and—By G. C. PFEFFER, February, 1935, 91.
General Discussion: Electric Overhead Traveling Cranes—By H. W. BALL, LEROY BROOKS, B. R. SHOVER, J. L. YOUNG, W. E. MILLER, G. R. CARROLL, A. W. MCAULY, R. J. HARRY, J. FARRINGTON, M. J. CONWAY, AND W. A. MARSHALL, February, 1935, 99.
General Maintenance—By A. W. DUNCAN, February, 1935, 98.
General Maintenance—By C. W. UPTON, February, 1935, 96.
General Maintenance—By T. B. MCELRAY, February, 1935, 97.
General Purpose Motors for Steel Mill Applications—By W. B. SNYDER, April, 1935, 214.
General Purpose Motors—Steel Mill Applications of—G. A. CALDWELL, May, 1935, 294.
Generation of Power in Industry by Diesel Engines Using Heavy Fuel Oils, The—By J. H. G. MCCONECHY AND K. E. DEROSAY, May, 1935, 297.

H

Heating Furnaces, High Temperature Conveyors, A Novel Type for—By W. E. BLYTHE, October, 1935, 16.
Heating Steel—Control of Scale Formation in—By T. B. BECHTEL, January, 1935, 26.
Heating of Steel—Controlled Atmosphere Applications to—By T. B. BECHTEL, November, 1935, 1.
Heating with Gaseous Fuels—Theory and Practice of Immersion—By E. B. DUNKAK, March, 1935, 167.
Heavy Fuel Oils—The Generation of Power in Industry by Diesel Engines Using—By J. H. G. MCCONECHY AND K. E. DEROSAY, May, 1935, 297.
High Temperature Conveyors, A Novel Type for Heating Furnaces—By W. E. BLYTHE, October, 1935, 16.
Human Element in Industry, The—Industrial Relations—By ARTHUR H. YOUNG, October, 1935, 11.

I

Immersion Heating with Gaseous Fuels—Theory and Practice of—By E. B. DUNKAK, March, 1935, 167.
Importance of A. I. & S. E. E. Convention and Iron and Steel Exposition—By E. J. KULAS, AND T. M. GIRDLER, September, 1935, 18.
Importance of Replacement of Obsolete Equipment in Steel Mills—By D. M. PETTY, August, 1935, 10.
Index for 1934—Iron and Steel Engineer—January, 1935, 34.
Individual Motor Drives for Runout Tables and Coiler Rolls—By W. B. SNYDER AND L. E. HILDEBRAND, December, 1935, 16.
Individual Motor Drives for Run Out Tables and Coilers—By F. E. HARRELL, AND C. V. GREGORY, August, 1935, 1.
Industrial Fuels, Propane and Butane as—By E. A. JAMISON AND W. H. BATEMAN, April, 1935, 209.
Industrial Relations, The Human Element in Industry—By ARTHUR H. YOUNG, October, 1935, 11.
Industrial Research—A Challenge to the Society, An Era of—By HARRY E. SHELDON, September, 1935, 28.
Industries During the Year 1934—Electric Motors over 300 Horsepower Applied to Main Roll Drives in the Iron and Steel and Allied—January, 1935, 33.
Industry—Industrial Relations, The Human Element in—By ARTHUR H. YOUNG, October, 1935, 11.
Industry Diesel by Engines Using Heavy Fuel Oils—The Generation of Power in—By J. H. G. MCCONECHY AND K. E. DEROSAY, May, 1935, 297.
Industry During the Year 1934—Developments in the Iron and Steel—January, 1935, 29.
Industry, Flat Rolled Steel Products, Processing for Automotive—By R. J. WEAN, December, 1935, 12.
Industry—Future of Steel—By J. FRANK BEAMAN, September, 1935, 30.
Industry—Progress of Electric Welding in the Steel—By H. J. BOWLES, May, 1935, 285.
Influence of Roll Neck Deflection on Life of Anti-Friction Bearings—By A. H. FRAUENTHAL, June, 1935, 356.
Influencing Its Production—Flat Rolling of Steel, Factors—By C. L. MCGRANAHAN, December, 1935, 1.
Iron and Steel and Allied Industries During the Year 1934—Electric Motors over 300 Horsepower Applied to Main Roll Drives in the—January, 1935, 33.
Iron and Steel Engineer Index for 1934—January, 1935, 34.
Iron and Steel Exposition—Economic Importance of A. I. & S. E. E. Convention and—By E. J. KULAS AND T. M. GIRDLER, September, 1935, 18.
Iron and Steel Industry During the Year 1934—Developments in the—January, 1935, 29.

L

Laminated Bearings Their Use in Different Types of Rolling Mills—By H. F. HORNE, November, 1935, 12.
Life of Anti-Friction Bearings—Influence of Roll Neck Deflection on—By A. H. FRAUENTHAL, June, 1935, 356.
Lift Electric Trucks in Steel Mills—Fork—By C. H. MOELLER, January, 1935, 23.
Lightning and Lightning Protection—By H. E. BUSSEY, May, 1935, 301.
Lightning Protection—Lightning and—By H. E. BUSSEY, May, 1935, 301.
Lightning Protection for Power Systems—By B. VAN NESS, JR. AND EDWARD HANSSON, February, 1935, 73.
Lubricants for Cold Rolling of Strip Steel—Selection of—By R. W. MOORE AND E. S. REYNOLDS, December, 1935, 24.
Lubrication, Gears and Pinions, Shafting, Bearings—By J. FARRINGTON, February, 1935, 95.

M

Main Roll Drives in the Iron and Steel and Allied Industries, During the Year 1934—Electric Motors over 300 Horsepower Applied to—January, 1935, 33.
Maintenance Crane Bridges and Trolleys—By F. D. EGAN, February, 1935, 92.
Maintenance, General—By A. W. DUNCAN, February, 1935, 98.
Maintenance, General—By T. B. MCELRAY, February, 1935, 97.
Maintenance, General—By C. W. UPTON, February, 1935, 96.
Maintenance of Roll Neck Bearings—By H. D. ROBB, June, 1935, 342.
Maintenance Problems on Old Cranes—By G. W. BAUMGARTEN, February, 1935, 102.
Measuring Device—Automatic Sheet—By GORDON W. FIRST, May, 1935, 292.
Metallurgical Furnaces—Use of Automatic Control on—By A. J. BOYNTON, March, 1935, 159.
Mill Applications—General Purpose Motors for Steel—By W. B. SNYDER, April, 1935, 214.
Mill Applications of General Purpose Motors—Steel—By G. A. CALDWELL, May, 1935, 294.
Mill Developments Report of A.I. & S.E.E. Committee—Steel—By W. H. BURR, September, 1935, 34.
Mill Furnaces—Automatic Control and Use of Fuels in Steel—By A. J. FISHER, March, 1935, 149.
Mill Screwdowns—Electric Controllers for Three-High Sheet Roughing—By J. J. MELLON, July, 1935, 430.
Mills and Rod Mills—Roller Bearing Applications in Continuous Strip—By S. M. WECKSTEIN, October, 1935, 23.
Mills—A Self-Aligning Device for the Work Rolls of Four High—By J. H. HITCHCOCK, June, 1935, 354.
Mills—Fork Lift Electric Trucks in Steel—By C. H. MOELLER, January, 1935, 23.
Mills—Importance of Replacement of Obsolete Equipment in Steel—By D. M. PETTY, August, 1935, 10.
Mills in Service—Tabulation of Applications of Anti-Friction Bearings to Roll Necks of Steel Rolling—September, 1935, 75.

M—(Continued)

Mills—Laminated Bearings, Their Use in Different Types of Rolling—By H. F. Horne, November, 1935, 12.
Mills—New Fork Truck Speeds Operation in Tin Plate—By E. I. Walsh, January, 1935, 24.
Mills—Oil Flooded Bearings, Uses in Steel Rolling—By J. H. Hitchcock, November, 1935, 14.
Mills—Roller Bearing Applications in Continuous Strip Mills and Rod—By S. M. Weckstein, October, 1935, 23.
Mills—Roll Table Equipment for Modern Wide Strip—By G. A. Caldwell and S. F. Henderson, December, 1935, 29.
Mills—Selection of Equipment for DC Power in Rolling—By C. Lynn, August, 1935, 17.
Mills—Wide Strip—By J. H. Van Campen, June, 1935, 367.
Modern Blast Furnace—The Development of the—By Arthur G. McKee, January, 1935, 1.
Modern Wide Strip Mills—Roll Table Equipment for—By G. A. Caldwell and S. F. Henderson, December, 1935, 29.
Motor Drives for Runout Tables and Coiler Rolls—Individual—By W. B. Snyder and L. E. Hildebrand, December, 1935, 16.
Motor Drives for Run Out Tables and Coilers—Individual—By F. E. Harrell, and C. V. Gregory, August, 1935, 1.
Motors and Gears—Crane—By G. C. Pfeffer, February, 1935, 91.
Motors for Steel Mill Applications, General Purpose—By W. B. Snyder, April, 1935, 214.
Motors over 300 Horsepower Applied to Main Roll Drives in the Iron and Steel and Allied Industries, During the year 1934—Electric—January, 1935, 33.
Motors—Steel Mill Applications of General Purpose—By G. A. Caldwell, May, 1935, 294.

N

Natural Gas in Steel Plants—By Karl Emmerling, June, 1935, 337.
Neck Bearings—Field Drawing of Roll—By S. F. Keener, June, 1935, 345.
Neck Bearings—Maintenance of Roll—By H. D. Robb, June, 1935, 342.
Neck Bearings—Roll—By C. J. Klein, April, 1935, 238.
Neck Bearings—Roll—G. Palmgren, June, 1935, 347.
Necks and Other Purposes—Composition Bearings for Roll—By H. M. Richardson, November, 1935, 5.
Neck Deflection on Life of Anti-Friction Bearings—Influence of Roll—By A. H. Frauenthal, June, 1935, 356.
Necks of Steel Rolling Mills in Service—Tabulation of Applications of Anti-Friction Bearings to Roll—September, 1935, 75.
New Fork Truck Speeds Operation in Tin Plate Mills—By E. I. Walsh, January, 1935, 24.
November—Steel Employment and Payrolls Rise in—January, 1935, 20.

O

Obsolete Equipment in Steel Mills—Importance of Replacement of—By D. M. Petty, August, 1935, 10.
Oil Flooded Bearings, Uses in Steel Rolling Mills—By J. H. Hitchcock, November, 1935, 14.
Oils—The Generation of Power in Industry by Diesel Engines Using Heavy Fuel—By J. H. G. McConechy and K. E. DeRosay, May, 1935, 297.
Old Cranes—Maintenance Problems on—By G. W. Baumgarten, February, 1935, 102.
Open Hearth Control—By M. J. Conway, September, 1935, 31.
Open Hearth Furnaces—The Developments in the Design and Operation of—By R. S. Bower, July, 1935, 413.
Operated Crane Statistics 1934—Electrically—January, 1935, 28.
Operation in Tin Plate Mills—New Fork Truck Speeds—By E. I. Walsh, January, 1935, 24.
Operation of Open Hearth Furnaces—The Developments in the Design and—By R. S. Bower, July, 1935, 413.
Overhead Traveling Cranes—Electric—By R. J. Harry, February, 1935, 84.

P

Payrolls Rise in November—Steel Employment and—January, 1935, 20.
Pinions, Shafting, Bearings, Lubrication, Gears and—By J. Farrington, February, 1935, 95.
Pits—Soaking—By G. R. McDermott, June, 1935, 369.
Plants—Natural Gas in Steel—By Karl Emmerling, June, 1935, 337.
Power in Rolling Mills—Selection of Equipment for DC.—By C. Lynn, August, 1935, 17.
Power Systems—Lightning Protection for—By B. Van Ness, Jr. and Edward Hansson, February, 1935, 73.
Practice of Immersion Heating with Gaseous Fuels—Theory and—By E. B. Dunkak, March, 1935, 167.
Preset Screwdown Control—Automatic—By W. M. Ballenger, July, 1935, 434.
Problems on Old Cranes, Maintenance—By G. W. Baumgarten, February, 1935, 102.
Processing for Automotive Industry, Flat Rolled Steel Products—By R. J. Wean, December, 1935, 12.
Production—Flat Rolling of Steel, Factors Influencing Its—By C. L. McGranahan, December, 1935, 1.
Products, Processing for Automotive Industry—Flat Rolled Steel—By R. J. Wean, December, 1935, 12.
Products—Steel in Federal Projects, Billion Dollars for Steel and Allied—By Edward H. Foley, October, 1935, 31.
Progress in their use—Composition Bearings, Recent—By K. T. MacGill, November, 1935, 9.
Progress in 1934—Cast Roll—By F. C. T. Daniels, January, 1935, 25.
Progress of Electric Welding in the Steel Industry—By H. J. Bowles, May, 1935, 285.
Projects, Billion Dollars for Steel and Allied Products, Steel in Federal—By Edward H. Foley, October, 1935, 31.
Propane and Butane as Industrial Fuels—By E. A. Jamison and W. H. Bateman, April, 1935, 209.
Protection for Power Systems—Lightning—By B. Van Ness, Jr. and Edward Hansson, February, 1935, 73.
Protection—Lightning and Lightning—By H. E. Bussey, May, 1935, 301.
Purpose Motors for Steel Mill Applications—General—By W. B. Snyder, April, 1935, 214.
Purpose Motors—Steel Mill Applications of General—By G. A. Caldwell, May, 1935, 294.

R

Rails—Cranes—By G. R. Carroll, February, 1935, 95.
Rails—Bumpers—Track Wheels—By J. A. Burg, February, 1935, 93.
Recent Progress in their Use—Composition Bearings—By K. T. MacGill, November, 1935, 9.
Relations, Industrial—The Human Element in Industry—By Arthur Young, October, 1935, 11.
Replacement of Obsolete Equipment in Steel Mills—Importance of—By D. M. Petty, August, 1935, 10.
Report of A.I. & S.E.E. Committee—Steel Mill Developments—By W. H. Burr, September, 1935, 34.
Research—A Challenge to the Society, An Era of Industrial—By Harry E. Sheldon, September, 1935, 28.
Rise in November—Steel Employment and Payrolls—January, 1935, 20.
Rod Mills—Roller Bearing Applications in Continuous Strip Mills and—By S. M. Weckstein, October, 1935, 23.
Roll Drives in the Iron and Steel and Allied Industries, During the Year 1934—Electric Motors over 300 Horsepower Applied to Main—January, 1935, 33.
Roll Neck Bearings—By C. J. Klein, April, 1935, 238.
Roll Table Equipment for Modern Wide Strip Mills—By G. A. Caldwell, and S. F. Henderson, December, 1935, 29.
Rolled Steel Products, Processing for Automotive Industry—Flat—By R. J. Wean, December, 1935, 12.
Roll Neck Bearings—By G. Palmgren, June, 1935, 347.
Roll Neck Bearings—Field Drawing of—By S. F. Keener, June, 1935, 345.
Roll Neck Bearings—Maintenance of—By H. D. Robb, June, 1935, 342.
Roll Neck Deflection on Life of Anti-Friction Bearings—Influence of—By A. H. Frauenthal, June, 1935, 356.
Roll Necks and Other Purposes—Composition Bearings for—By H. M. Richardson, November, 1935, 5.
Roll Necks of Steel Rolling Mills in Service—Tabulation of Applications of Anti-Friction Bearings to—September, 1935, 75.
Roll Progress in 1934—Cast—By F. C. T. Daniels, January, 1935, 25.
Roller Bearing Applications, In Continuous Strip Mills and Rod Mills—By S. M. Weckstein, October, 1935, 23.
Rolling Mills in Service—Tabulation of Applications of Anti-Friction Bearings to Roll Necks of Steel—September, 1935, 75.
Rolling Mills—Oil Flooded Bearings, uses in Steel—By J. H. Hitchcock, November, 1935, 14.
Rolling Mills—Selection of Equipment for DC Power in—By C. Lynn, August, 1935, 17.
Rolling Mills—Laminated Bearings, Their Use in Different Types of—By H. F. Horne, November, 1935, 12.
Rolling of Steel—Flat—Factors Influencing Its Production—By C. L. McGranahan, December, 1935, 1.
Rolling of Strip Steel—Selection of Lubricants for Cold—By R. W. Moore and E. S. Reynolds, December, 1935, 24.
Rolls—Individual Motor Drives for Runout Tables and Coiler—By W. B. Snyder and L. E. Hildebrand, December, 1935, 16.
Rolls of Four High Mills—A Self-Aligning Device for the Work—By J. H. Hitchcock, June, 1935, 354.
Roughing Mill Screwdowns—Electric Controllers for Three-High Sheet—By J. J. Mellon, July, 1935, 430.
Runout Tables and Coiler Rolls—Individual Motor Drives for—By W. B. Snyder and L. E. Hildebrand, December, 1935, 16.
Run Out Tables and Coilers—Individual Motor Drives for—By F. E. Harrell, and C. V. Gregory, August, 1935, 1.

S

Safety—Crane—By R. F. Gale, February, 1935, 87.
Scale Formation in Heating Steel—Control of—By T. B. Bechtel, January, 1935, 26.
Screwdown Control—By F. J. Burd, July, 1935, 432.
Screwdown Control—Automatic—By R. M. Bayle, July, 1935, 425.
Screwdown Control—Automatic Preset—By W. M. Ballenger, July, 1935, 434.
Screwdowns—Electric Controllers for Three-High Sheet Roughing Mill—By J. J. Mellon, July, 1935, 430.
Selection of Equipment for DC Power In Rolling Mills—By C. Lynn, August, 1935, 17.
Selection of Lubricants for Cold Rolling of Strip Steel—By R. W. Moore and E. S. Reynolds, December, 1935, 24.
Self-Aligning Device for the Work Rolls of Four High Mills—A—By J. H. Hitchcock, June, 1935, 354.
Service—Tabulation of Applications of Anti-Friction Bearings to Roll Necks of Steel Rolling Mills in—September, 1935, 75.
Shafting, Bearings, Lubrication, Gears and Pinions—By J. Farrington, February, 1935, 95.
Sheet Measuring Device—Automatic—By Gordon W. First, May, 1935, 292.
Sheet Roughing Mill Screwdowns—Electric Controllers for Three-High—By J. J. Mellon, July, 1935, 430.
Speeds Operation in Tin Plate Mills—New Fork Truck—By E. I. Walsh, January, 1935, 24.
Soaking Pits—By G. R. McDermott, June, 1935, 369.
Society—An Era of Industrial Research, A Challenge to the—By Harry E. Sheldon, September, 1935, 28.
Statement for 1935—A—By F. A. Merrick, January, 1935, 20.
Statistics 1934—Electrically Operated Crane—January, 1935, 28.
Steel and Allied Industries During the Year 1934—Electric Motors over 300 Horsepower Applied to Main Roll Drives in the Iron and—January, 1935, 33.
Steel and Allied Products—Steel in Federal Projects, Billion Dollars for—By Edward H. Foley, October, 1935, 31.
Steel—Control of Scale Formation in Heating—By T. B. Bechtel, January, 1935, 26.
Steel—Controlled Atmosphere Applications to Heating of—By T. B. Bechtel, November, 1935, 1.
Steel Engineer Index for 1934—Iron and—January, 1935, 34.
Steel Industry During the Year 1934—Developments in the Iron and—January, 1935, 29.
Steel Exposition—Economic Importance of A.I. & S.E.E. Convention and Iron and—By E. J. Kulas and T. M. Girdler, September, 1935, 18.
Steel—Flat Rolling of, Factors Influencing Its Production—By C. L. McGranahan, December, 1935, 1.
Steel Industry—Future of—By J. Frank Beaman, September, 1935, 30.
Steel Employment and Payrolls Rise in November—January, 1935, 20.
Steel Industry—Progress of Electric Welding in the—By H. J. Bowles, May, 1935, 285.
Steel in Federal Projects, Billion Dollars for Steel and Allied Products—By Edward H. Foley, October, 1935, 31.
Steel Mill Applications—General Purpose Motors for—By W. B. Snyder, April, 1935, 214.
Steel Mill Applications of General Purpose Motors—G. A. Caldwell, May, 1935, 294.
Steel Mill Developments Report of A.I. & S.E.E. Committee—By W. H. Burr, September, 1935, 34.
Steel Mill Furnaces, Automatic Control and Use of Fuels in—By A. J. Fisher, March, 1935, 149.
Steel Mills—Fork Lift Electric Trucks in—By C. H. Moeller, January, 1935, 23.
Steel Mills—Importance of Replacement of Obsolete Equipment in—By D. M. Petty, August, 1935, 10.
Steel Plants—Natural Gas in—By Karl Emmerling, June, 1935, 337.
Steel Plants of the U.S.S.R.—The Trend of Electrification in the—By P. L. Litvin, May, 1935, 290.
Steel Products, Processing for Automotive Industry—Flat Rolled—By R. J. Wean, December, 1935, 12.
Steel Rolling Mills in Service—Tabulation of Applications of Anti-Friction Bearings to Roll Necks of—September, 1935, 75.
Steel Rolling Mills—Oil Flooded Bearings, uses in—By J. H. Hitchcock, November, 1935, 14.
Steel—Selection of Lubricants for Cold Rolling of Strip—By R. W. Moore and E. S. Reynolds, December, 1935, 24.
Steel—Strip—By J. H. Van Campen, April, 1935, 239.
Strip Mills and Rod Mills—Roller Bearing Applications in Continuous—By S. M. Weckstein, October, 1935, 23.
Strip Mills—Wide—By J. H. VanCampen, June, 1935, 267.
Strip Mills—Roll Table Equipment for Modern Wide—By C. A. Caldwell and S. F. Henderson, December, 1935, 29.
Strip Steel—By J. H. Van Campen, April, 1935, 239.
Strip Steel—Selection of Lubricants for Cold Rolling of—By R. W. Moore and E. S. Reynolds, December, 1935, 24.
Systems—Lightning Protection for Power—By B. Van Ness, Jr., and Edward Hansson, February, 1935, 73.

T

Table Equipment for Modern Wide Strip Mills—Roll—By G. A. Caldwell and S. F. Henderson, December, 1935, 29.
Tables and Coilers—Individual Motor Drives for Run Out—By F. E. Harrell and C. V. Gregory, August, 1935, 1.
Tables and Coiler Rolls—Individual Motor Drives for Runout—By W. B. Snyder and L. E. Hildebrand, December, 1935, 16.
Tabulation of Applications of Anti-Friction Bearings to Roll Necks of Steel Rolling Mills in Service—September, 1935, 75.
Temperature Conveyers, High, A Novel Type for Heating Furnaces—By W. E. Blythe, October, 1935, 16.
Theory and Practice of Immersion Heating with Gaseous Fuels—By E. B. Dunkak, March, 1935, 167.
Thermit Welding—By J. B. Tinnon, February, 1935, 104.
Three-High Sheet Roughing Mill Screwdowns—Electric Controllers for—By J. J. Mellon, July, 1935, 430.
Tin Plate Mills—New Fork Truck Speeds Operation in—By E. I. Walsh, January, 1935, 24.
Track Wheels—Rails—Bumpers—By J. A. Burg, February, 1935, 93.
Transportation—By G. N. Harmon, January, 1935, 22.
Traveling Cranes—Electric Overhead—By R. J. Harry, February, 1935, 84.
Trend of Electrification in the Steel Plants of the U.S.S.R.—The—By P. L. Litvin, May, 1935, 290.
Trolleys and Bridges—By B. A. E. Rosenquist, February, 1935, 102.
Trolleys—Maintenance Crane Bridges and—By F. D. Egan, February, 1935, 92.
Truck Speeds Operation in Tin Plate Mills—New Fork—By E. I. Walsh, January, 1935, 24.
Trucks in Steel Mills—Fork Lift Electric—By C. H. Moeller, January, 1935, 23.
Type for Heating Furnaces, High Temperature Conveyors, A Novel—By W. E. Blythe, October, 1935, 16.
Types of Rolling Mills—Laminated Bearings, Their Use in Different—H. F. Horne, November, 1935, 12.

U

Use—Composition Bearings, Recent Progress in their—By K. T. MacGill, November, 1935, 9.
Use in Different Types of Rolling Mills—Laminated Bearings, Their—By H. F. Horne, November, 1935, 12.
Use of Automatic Control on Metallurgical Furnaces—By A. J. Boynton, March, 1935, 159.
Use of Fuels in Steel Mill Furnaces—Automatic Control and—By A. J. Fisher, March, 1935, 149.
U.S.S.R.—The Trend of Electrification in the Steel Plants of the—By P. L. Litvin, May, 1935, 290.
Uses in Steel Rolling Mills—Oil Flooded Bearings—By J. H. Hitchcock, November, 1935, 14.
Using Heavy Fuel Oils—The Generation of Power in Industry by Diesel Engines—By J. H. G. McConechy and K. E. DeRosay, May, 1935, 297.

W

Welding Developments During the Year 1934-1935—By Grover A. Hughes, September, 1935, 65.
Welding of Aluminum Alloys—Recent Developments in the—By D. I. Bohn, January, 1935, 16.
Welding in the Steel Industry—Progress of Electric—By H. J. Bowles, May, 1935, 285.
Welding, Thermit—By J. B. Tinnon, February, 1935, 104.
Wide Strip Mills—J. H. VanCampen, June, 1935, 367.
Wide Strip Mills—Roll Table Equipment for Modern—By G. A. Caldwell and S. F. Henderson, December, 1935, 29.
Works Rolls of Four High Mills—A Self-Aligning Device for the—By J. H. Hitchcock, June 1935, 354.
Wheels—Cranes—By J. C. Keel, February, 1935, 87.
Wheels—Cranes—By E. S. Sawtelle, February, 1935, 92.
Wheels, Rails, Bumpers, Track—By J. A. Burg, February, 1935, 93.

Y

Year 1934—Electric Motors over 300 Horsepower Applied to Main Roll Drives in the Iron and Steel and Allied Industries During the—January, 1935, 33.
300 Horsepower Applied to Main Roll Drives in the Iron and Steel and Allied Industries, During the Year 1934—Electric Motors over—January, 1935, 33.
1934—Cast Roll Progress in—By F. C. T. Daniels, January, 1935, 25.
1934—Developments in the Iron and Steel Industry during the Year—January, 1935, 29.
1934—Electric Motors over 300 Horsepower Applied to Main Roll Drives in the Iron and Steel and Allied Industries, During the Year—January, 1935, 33.
1934—Electrically Operated Crane Statistics—January, 1935, 28.
1934—Iron and Steel Engineer Index for—January, 1935, 34.
1934-1935—Welding Developments During the Year—By Grover A. Hughes, September, 1935, 65.
1935—A Statement for—By F. A. Merrick, January, 1935, 20.

BRENT WILEY ELECTED

MANAGING DIRECTOR OF THE ASSOCIATION

BRENT WILEY

TO SUCCEED the late John Fredrick Kelly as Managing Director of the Association of Iron and Steel Electrical Engineers, the Board of Directors of the Society, at a meeting on December 14, elected Mr. Brent Wiley. This will be effective January 1, 1936.

Cognizant of Mr. Wiley's leadership and executive ability to carry on the work that was instituted by the late John F. Kelly, it is the unanimous opinion of the Board of Directors that Mr. Wiley is well suited to discharge the duties of the Managing Directorship of the Society.

A graduate of Rose Polytechnic Institute in 1898 with a B.S. degree in Electrical Engineering, and later being awarded an M.S. degree, Mr. Wiley has been closely associated with the steel industry for the past 37 years.

After leaving college, he spent one year in the Electrical Department of the Ohio Works of the Carnegie-Illinois Steel Corporation, later going to the Homestead Works of the same company as the Assistant to the Electrical Superintendent.

Leaving the Carnegie-Illinois Steel Corporation in 1904, Mr. Wiley went with the Wellman-Seaver-Morgan Company in Cleveland as Electrical Engineer. In 1906 he left this company and became associated with the Westinghouse Electric & Manufacturing Company with whom he spent the next 25 years. While affiliated with this company, his duties were largely confined to the subject of the development of the electrification of the steel industry, which work required a great deal of investigation and engineering work.

A member of the Association for the past 25 years, Mr. Wiley is conversant with and possessed of a deep appreciation of the Association's work in advancing the art of engineering to the steel industry.

DISCUSSION

(Continued from page 39)

or increased cost of first installation is fully justified if the gain in operation is worth the increased cost.

Early in the consideration of a new project, would it not be very desirable for the engineers of the steel plant, the engineers of the company building the mill, and the engineers of several companies who might supply electrical equipment, to meet and discuss the whole proposition, there decide on what assumption should be made in connection with the furnishing of the electrical equipment. The engineers from several electrical companies could be invited. The commercial consideration should be eliminated during such a conference. It is believed that the conclusion as to the electrical equipment, by the engineers from the different electrical companies, would not materially differ if their conclusions were based on the same assumptions.

Possibly the most important assumption in connection with the electrical equipment, is the time for acceleration and deceleration. Usually, there appears to be considerable uncertainty as to just what times are going to be required in the mill operation. If a decision could be reached as to the assumption to be made, there would be little difference as to the size of motor-generator sets and the motors to be used to drive in the table. These times are not yet very well established, and a great deal of information will be obtained in connection with the new continuous mills which are now being installed throughout the industry.

Tribute should be paid to the steel companies which are installing these new continuous mills. The engineers of these steel companies are constantly bringing in new ideas which the electrical companies are endeavoring to interpret in the terms of the best equipment that can be supplied for the purpose.

Would it not be possible to establish certain standards for the motor-generator sets to drive these frequency control tables. 500 Kva. has frequently been used, and this seems to be a very good unit. Usually there are at least four or five sets. If a total of 4000 Kva. were needed on a mill, it might be divided into eight 500 Kva. sets or five 800 Kva. sets. In many ways it would be desirable to have the eight 500 Kva. sets. Usually the tables could be so planned as to effectively use eight 500 sets instead of five 800 sets. Often after the mill is in operation, it is found desirable to so change the schemes as to require additional sets. The purchase of a standard set would be very desirable, and if this standardization is possible, the size should not be too large.

Consideration of acceleration through frequency control, or through group starting, is a very fascinating study. From several standpoints, the frequency control is desirable. From other standpoints, the group control is desirable. There is a certain simplicity in connection with throwing a group on to the set, with the set operating at the high frequency, but what seems even more important is the rapidity with which the motors driving the table rollers will accelerate. When the total time of acceleration is in the neighborhood of 4 or 5 seconds, group starting seems more desirable. When the accelerating time is 8 or 9 seconds, frequency control of the set itself seems more desirable, since in the longer period there is sufficient time for the field weakening motor to accelerate from base speed to the high frequency desired.

When group starting is selected, usually the set will be somewhat larger with a somewhat higher first cost. However, it is very interesting to note that sets selected on the basis of group starting can readily be used in connection with frequency control, only minor changes in the control equipment being required. In general, it has been the experience in the steel mill that having sets somewhat larger that appeared to be necessary is a very desirable feature, since usually operations are speeded up even over those originally planned.

▲ ▲ ▲ ITEMS OF INTEREST ▲ ▲ ▲

Harry L. Brindle, as announced by Carnegie-Illinois Steel Corporation, has been appointed Assistant General Superintendent of the Youngstown District of the company. Mr. Brindle's service with the Carnegie Steel Company began in June, 1906, at the New Castle Works in the roll department. He was transferred to the Farrell Works as Assistant Master Mechanic in 1919; was made Assistant General Superintendent of the Farrell Works on February 1, 1926; and promoted to General Superintendent on June 1, 1931.

▲

Frederick B. Quigley, formerly Assistant General Superintendent of the Youngstown District of the Carnegie-Illinois Steel Corporation, has been appointed the General Superintendent of the Farrell Steel Works and Furnaces succeeding Mr. Brindle, who went to Youngstown. An employ of the Carnegie Company for the past 27 years, Mr. Quigley began his steel mill career in 1908 in the Blast Furnace department at Youngstown. He was made Superintendent of Blast Furnaces January 1, 1917; Superintendent of Open Hearth and Bessemer department January 1, 1922; and Assistant General Superintendent of the Youngstown District on February 1, 1927.

▲

W. W. Hill, superintendent of bar mills, Carnegie-Illinois Steel Corp., Duquesne, Pa., has retired as announced by the company.

Mr. Hill began his career in 1887 with the Westinghouse Airbrake in Old Allegheny City; leaving there in 1889 to go with the Aluminum Company of America, then known as the Pittsburgh Reduction Com-

H. L. BRINDLE

J. J. BOOTH

F. B. QUIGLEY

pany, located at Smallman Street, Pittsburgh. This plant was later moved to New Kensington, Pa., when Mr. Hill was placed in charge of operations.

Mr. Hill's service with the Carnegie Steel Company began in 1892 at the Homestead Steel Works, and he was later transferred to Duquesne Works, in 1902, as Supt. of the shipping dept., and since 1912, has been supt. of the bar mills.

▲

John P. McCaslin, formerly general superintendent, Corrigan-McKinney Steel Company, has been appointed superintendent of the bar mills of the Carnegie-Illinois Steel Corporation, at Duquesne, Pa., to succeed W. W. Hill, retired.

Mr. McCaslin has been rolling mill superintendent of Cambria Steel Company, Johnstown, Pa., 1914-1916; leaving this company to be the rolling mill superintendent of the Corrigan-McKinney Steel Company in Cleveland. In 1916 he was also made the superintendent of the open hearths of this company and promoted to general superintendent in 1933 in which capacity he served to November, 1935.

▲

R. F. Sanner, formerly Assistant Chief Maintenance Engineer of the Carnegie-Illinois Steel Corporation, Duquesne, Penna., has been appointed, effective December 16, Superintendent of Personnel of that plant. Mr. Sanner succeeds Ross L. Leffler who had recently been appointed Manager of Industrial Relations for the Pittsburgh district of the Carnegie-Illinois Steel Corporation.

Mr. Sanner has been affiliated with the Carnegie-Illinois Corporation at Duquesne since 1926 starting in the Electrical Department. December 1927 he was made the Assistant Electrical Engineer and in September 1932 he was promoted to the Assistant Chief Maintenance Engineer, which capacity he held until his recent advancement.

In his new capacity he will have charge of Welfare, Safety and Employment.

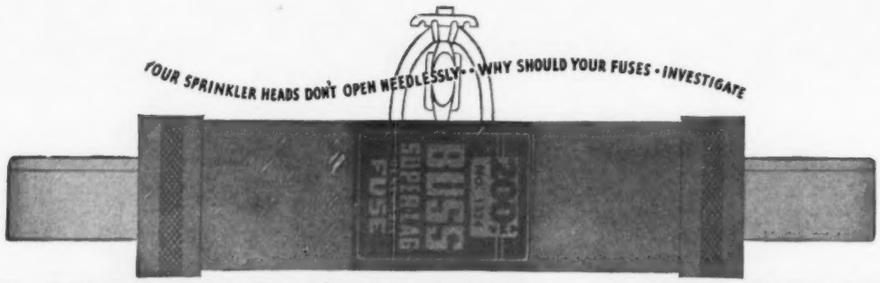
▲

J. J. Booth, newly appointed Assistant Chief Maintenance Engineer of the Carnegie-Illinois Steel Corporation, Duquesne, Penna., was born in Shelbina, Mo., in the year 1887. He graduated from the University of Missouri in 1910 with the degree of B.S. in Electrical Engineering. During the summer of 1910 he located with the Missouri and Kansas Bell Telephone Company at Kansas City, Mo. In Jan-

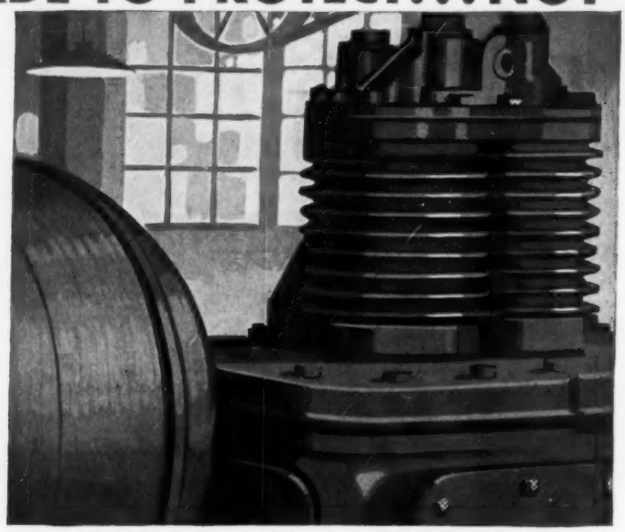
(Continued on page 62)

R. F. SANNER

J. P. McCASLIN



FUSES MADE TO PROTECT...NOT TO BLOW



GET THE FACTS:

"We have experienced difficulty on 800 ampere, three phase circuit (two 400 ampere fuses on each phase) which fed motors driving compressors . . . These fuses were letting go on an average of once a week until we replaced them with BUSS SUPER-LAG . . . Since then we have been running 3 months without a failure. Our shutdown worries have been eliminated."

So said Chief Electrician Deardorff of UNIVERSAL GYPSUM & LIME CO., York, Pa., in Fall of 1930. At a re-check on Sept. 25, 1935 he added—"these fuses are still in service not having blown since installation"—They are now starting their second 5 years of blow-free protection—see title of booklet.

EXECUTIVES DO NOT ALWAYS INTEREST THEMSELVES IN FUSES BUT THEY DO GET SEARCHINGLY INTERESTED IN.....

.....the RECURRING SHUTDOWNS caused by NEEDLESS BLOWS

"made to *protect* not to blow" is not a new departure with BUSS Fuses. It has been preached to maintenance men, production men, engineers and executives since the advent of the BUSS SUPER-LAG FUSE.

Thousands are profiting handsomely from INVESTIGATING the costs of and reasons for fool shutdowns caused by "self-blowing" fuses.

By charging those shutdown costs smack up against the fuses themselves the buyers now have a sane measure to judge fuse prices. Investigate....

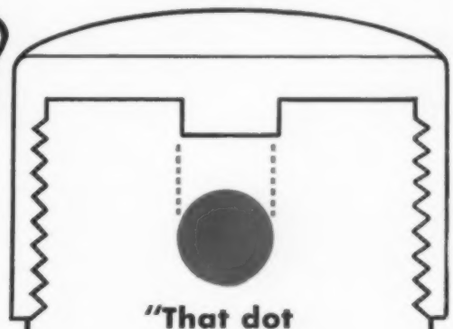
WHY BUSS FUSES DON'T BLOW NEEDLESSLY

10 FEATURES

in the design of the FUSE-CASE help make it possible and ....

The Super-Lag

development in the FUSE LINK completes the job.



"That dot is worth a million dollars to industry"

says a round-number enthusiast

to which our serious reply is "AND LOTS MORE"... for without that patented BUSS projection the contact between cap and link would be decidedly haphazard, beckoning for a self-imposed blow and a NEEDLESS shutdown.

But WITH it the entire force of screwing down the cap is concentrated in the small area of the projection.

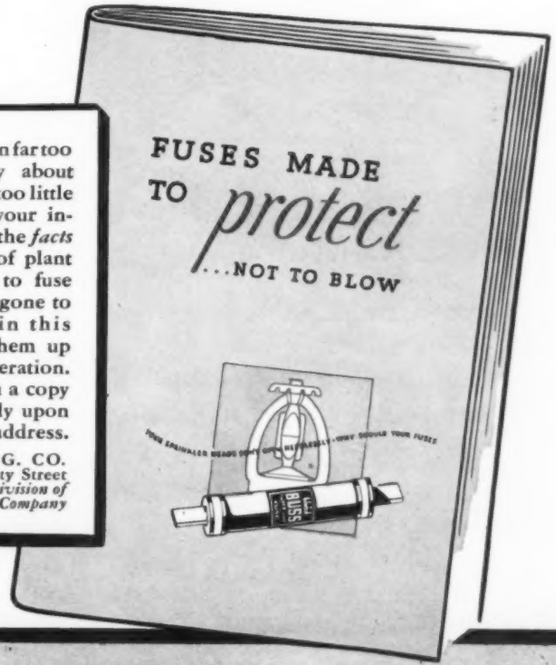
This heavy grinding pressure overcomes the slight irregularities, burrs, etc., that might interfere with ample contact.

Can't you picture the SURENESS of dirty contact as well as inadequate contact pressure if the projection were not there?

GET THE FACTS

THERE has been far too much theory about fuse action—far too little fact. Assuming your interest in getting the *facts* on the relation of plant operating costs to fuse design, we have gone to great lengths in this booklet to set them up for your consideration. We will mail you a copy gratis immediately upon receipt of your address.

BUSSMANN MFG. CO.
2536 West University Street
St. Louis, Mo.... *A Division of the McGraw Electric Company*



BUSS super-lag FUSES

ITEMS OF INTEREST

(Continued from page 59)

uary, 1911, Mr. Booth started work with the Westinghouse Electric & Manufacturing Company, East Pittsburgh Works.

In 1913 he took up work with the Carnegie Steel Company, Edgar Thomson Works, Electrical Engineering Department, and remained with the Carnegie Steel Company until March, 1924, at which time he transferred to National Tube Company, Gary Works, as Assistant Superintendent of the Electrical Department and was made Superintendent of this department in November, 1929. He has spent 22 years with subsidiary companies of the United States Steel Corporation.

Mr. Booth was President of the Association of Iron and Steel Electrical Engineers in 1931-1932, as well as being Chairman of the Chicago Section and other important posts in the Society.

▲

Frank V. Bush has been promoted to the position of service manager of the Allegheny Steel Company, filling the post vacated by M. E. Harris, recently advanced to assistant general manager. Mr. Bush began work with the company in 1920 in the order and billing department, later advancing to sales office manager which position he held until his recent promotion.

▲

Sydney Buckley has been elected president of the Shepard Niles Crane & Hoist Corporation and will be located at the main offices of this company at Montour Falls, N. Y. Mr. Buckley was formerly vice president and general manager of the Niles Division at Philadelphia.

▲

The following executives of the Youngstown District Carnegie-Illinois Steel Corporation, have been responsible for the construction and will be responsible for the operation of the new continuous hot strip mill.

L. N. McDonald, Gen. Supt., Youngstown District.

H. L. Brindle, Asst. Gen. Supt., in charge of Operations, Youngstown District.

H. J. Baugh, Asst. Gen. Supt., in charge of Production, Youngstown District.

W. D. Griffith, Supt. Bar and Hoop Mills, Youngstown Dist.

A. R. Schultz, Chief Mechanical Engineer, Youngstown Dist., under whose direction the Mill was designed.

L. M. Applegate, Chief Civil Engineer, Youngstown Dist.

Robert Backus, Master Mechanic, Youngstown District.

Thomas Backus, Asst. Master Mechanic, who was in direct charge of the mechanical construction.

Thomas B. McElray, Supt. Electrical Dept., Youngstown Dist., who supervised the erection of all electrical equipment.

Howard Linn, Supt. of the Mill, who will have direct charge of its operation.

PHILADELPHIA DISTRICT SECTION
ENGINEERS CLUB—1317 SPRUCE STREET
January 4, 1936—7:00 P.M.
Annealing Furnace Symposium

"Controlled Atmosphere and Fuel Fired Bright Annealing", A. L. Hollinger, Assistant Sales Manager in Charge of Steel Mill Division, Surface Combustion Corporation, Toledo, Ohio.

"Bright Annealing of Strip by the Batch Method", J. W. Allison, Industrial Heating Engineer, Westinghouse Electric & Manufacturing Company, Philadelphia, Penna.

"Controlled Atmosphere in Electrically Heated Furnaces", Harold E. Trent, President, Harold E. Trent Company, Philadelphia, Penna.

During the afternoon the members and their guests are invited to visit the Franklin Museum and Fels Planetarium on the Parkway.

PITTSBURGH DISTRICT SECTION
CARDINAL ROOM—WILLIAM PENN HOTEL
January 25, 1936—8:00 P.M.

"Developments in Cold Strip Mill Drives" by F. H. Mohler, Industrial Engineering Department, General Electric Company, Schenectady, N. Y.

Special Feature—Moving Pictures of the Continuous Hot Strip Mill and Cold Strip Mills of the Youngstown Sheet and Tube Company, Youngstown, Ohio, described by W. H. Texter, Advertising and Sales Promotion Department of the Youngstown Sheet and Tube Company, Youngstown, Ohio.

CHICAGO DISTRICT SECTION
PHIL SMIDT'S
January 7, 1936—

"The Problem of Motor Application for Continuous Mill Auxiliaries" by F. E. Harrell, Assistant Chief Engineer, Reliance Electric & Engineering Co., Cleveland, Ohio.

▲

OBITUARY

It is with deep regret that the Association announces the death of George H. McFeaters, electrical superintendent, Lorain Division, Carnegie-Illinois Steel Corporation, who died at his home in Johnstown, Pa., October 12 after a long illness.

Mr. McFeaters had been an active member of the society for the past 28 years being one of that small group of electrical engineers who met in Pittsburgh in 1907 and organized the Association of Iron and Steel Electrical Engineers. His passing removes one from the association ranks whose loyalty and interest will be sorely missed.

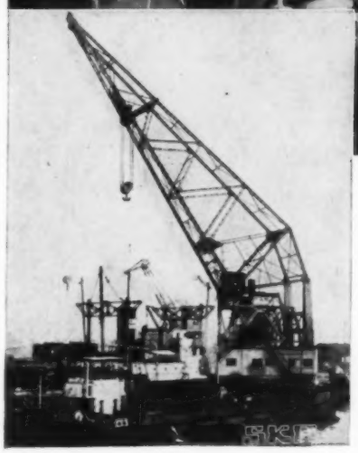
G. H. McFEATERS

An employ of the Lorain Company for the past 44 years, Mr. McFeaters had been superintendent of the electrical department for the past 8 years.

CRANES

BIG ONES···LITTLE ONES

SKF-EQUIPPED!



• Upper right: 480-ton gantry crane hook SKF-Equipped. Center: Typical steel mill crane SKF-Equipped. Lower left: 400-ton floating crane equipped with SKF Thrust Bearings.

FROM massive 500-ton floating cranes to portable hoists, SKF Bearings are widely used because of their exclusive characteristics.

Owing to their self-aligning properties, SKF Spherical Bearings are able to neutralize the weave in the frame when the crane is working. Their low coefficient of friction helps to overcome inertia in starting, stopping and running under heavy loads—an outstanding advantage, for a large amount of friction in the bearings greatly increases the strain in the driving mechanism.

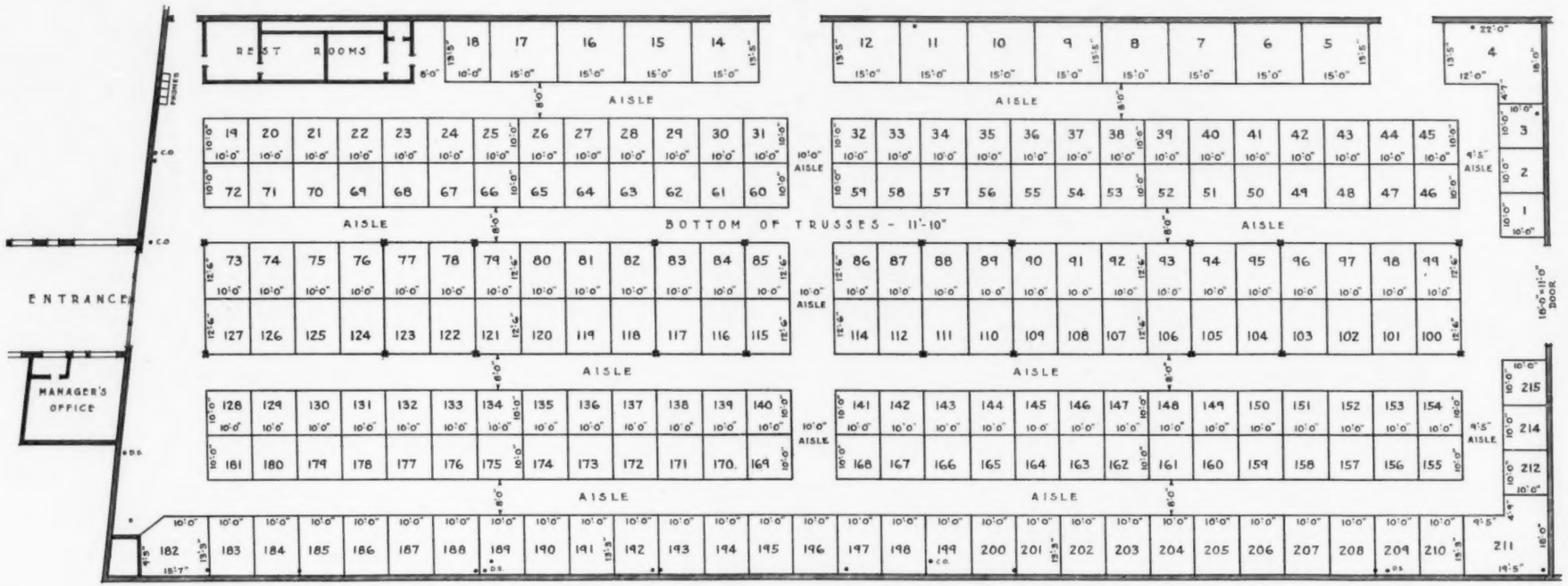
SKF pioneered with simplified bearing mountings that insure smooth acceleration, economical manufacture, ease in assembly, and a minimum of maintenance. In fact, SKF not only *make* bearings; they *engineer* them into your machine. Consult our engineering department for further details.

3502

SKF INDUSTRIES, INC., Front St. & Erie Ave., Phila., Pa.

1936

IRON AND STEEL EXPOSITION



SPONSORED AND CONTROLLED BY

ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS

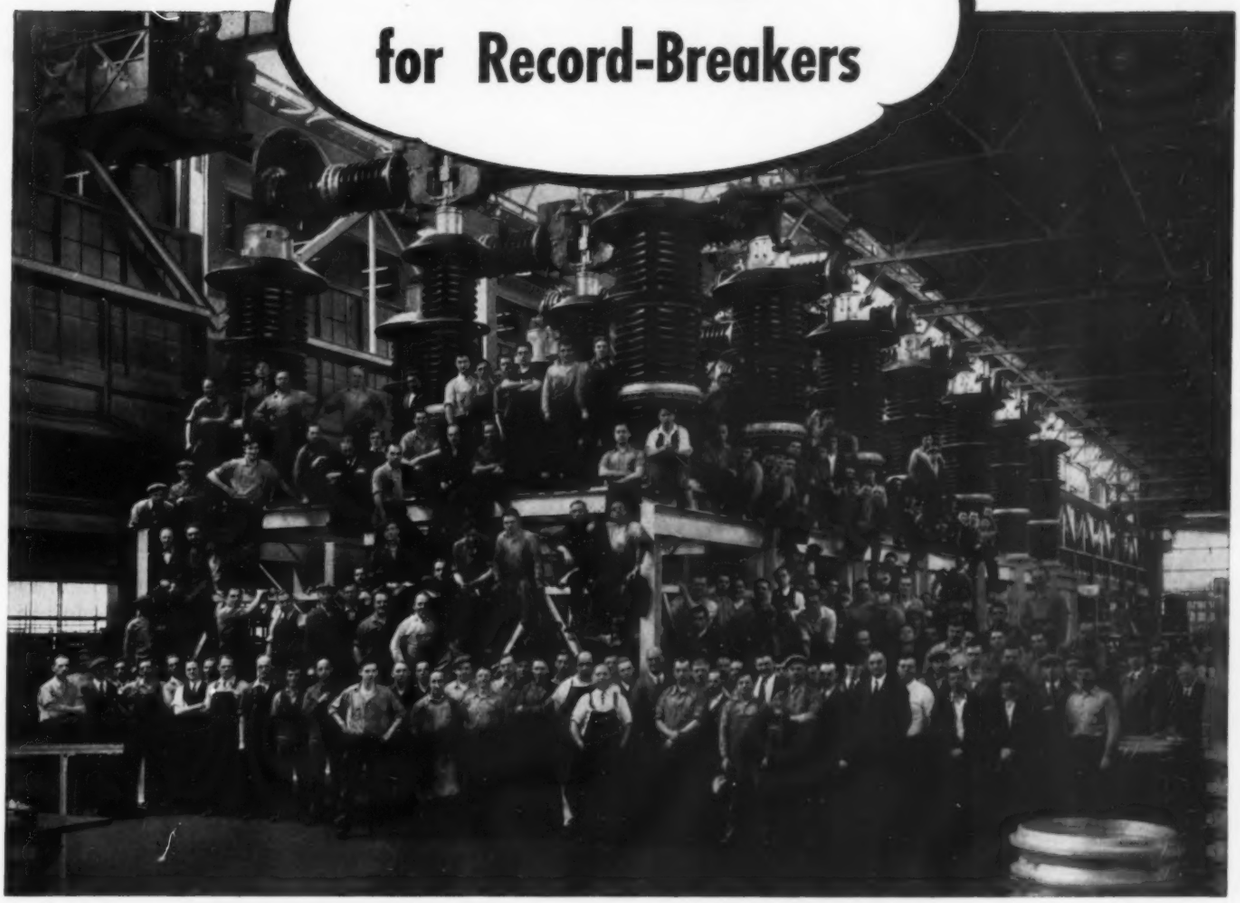
CONVENTION HALL - - CASS AVENUE - - DETROIT - - MICH.

SEPTEMBER 22 - 23 - 24 - 25, 1936

CONVENTION HALL
(South Cass Hall)
CASS AVENUE - DETROIT - MICH.

32nd CONVENTION
A - I - & - S - E - E
National Headquarters
1010 Empire Bldg. - Pittsburgh, Pa.

Ball Bearings for Record-Breakers



● These giant impulse circuit-breakers, built by the General Electric Company for the Boulder Dam—Los Angeles transmission line, have a rating of 5,000 amperes at 287,500 volts and operate at the record speed of 0.04 to 0.05 seconds.

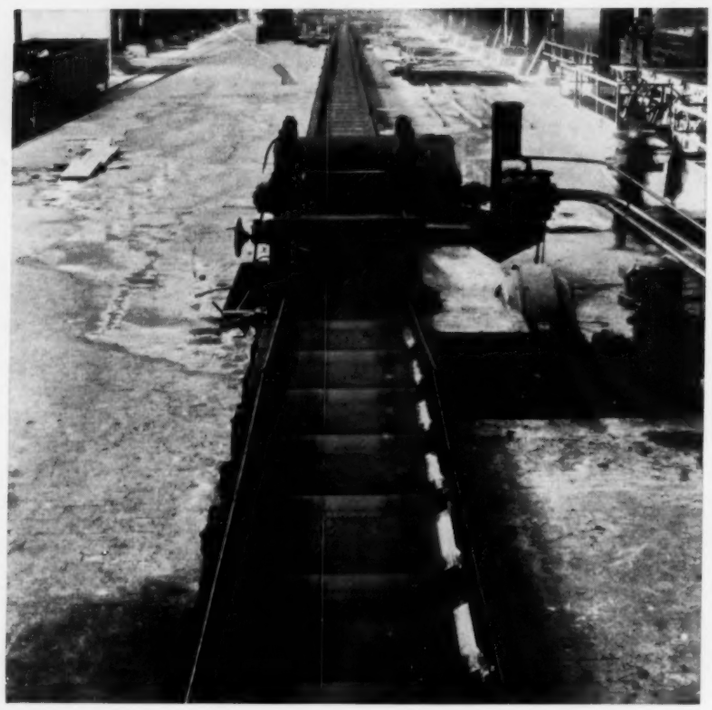
Down in the operating mechanism of each breaker are New Department Ball Bearings — used because their rolling ease, long life and dependability are features thoroughly established by record — proving them worthy components of these record-breaking circuit-breakers.

The New Departure Mfg. Company, Bristol, Connecticut; Detroit, Chicago, San Francisco.

Also Manufacturers of TRANSITORQ— the Infinitely Variable Speed Power Unit

2339

SCHLOEMANN



MOTOR-ROLLERS

(Schulte and other Patents)

You can avoid delays to your mills and high cost of maintenance of mill table by using our self-contained, fool-proof Motor-Rollers.

SCHLOEMANN

ENGINEERING CO.
Rolling Mill Machinery

PITTSBURGH, PA.
Hydraulic Presses

PERFORMANCE

Introducing Our New Drums

THAT CUTS COSTS

The "FOUR HORSEMEN" of Steel Mill Lubrication

DENSOIL GEARKOTE GEARARMOR METALICOIL

Operating costs are materially reduced with HODSON Lubrication. Performance over a long period, under a wide range of conditions, in an important way, establishes the facts.

There are several physical characteristics of these lubricants that make them outstandingly superior—establish unequalled performance records. Of especial importance are:

1. **They cushion and absorb shocks, lessening metal fatigue and prevent pitting and spalling of gear teeth.**
2. **They maintain a tough, protecting film between bearing surfaces, which prevents metal grab, scoring and cutting of bearings and gears.**

There Is No Valid Excuse for Not Using Hodson Lubrication

THE ADAMS-SCHUETTE LUBRICATING SYSTEMS

• • •

fulfill the maximum lubrication demands of the heaviest equipment, with a flexibility of quantity of grease and application periods, unapproached by any other method.

We offer you the benefit of our personal, practical experience and our services as consultants on your lubrication problems . . without obligation or charge

Hodson Lubrication Now!! Why Wait?
It's Costing You Money

THE HODSON CORPORATION

Lubrication Engineers & Manufacturers

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LEWIS TABLES

...FURNACE RUNOUT
...MERCHANT MILL
...BLOOMING MILL

LEWIS Foundry & Machine Company makes Furnace Runout Tables, Merchant Mill Tables, and Blooming Mill Tables, as well as tables for all types of rolling mill equipment.

These tables are equipped with anti-friction bearings. The bearings are arranged to remove one roll at a time without dismantling the complete table.

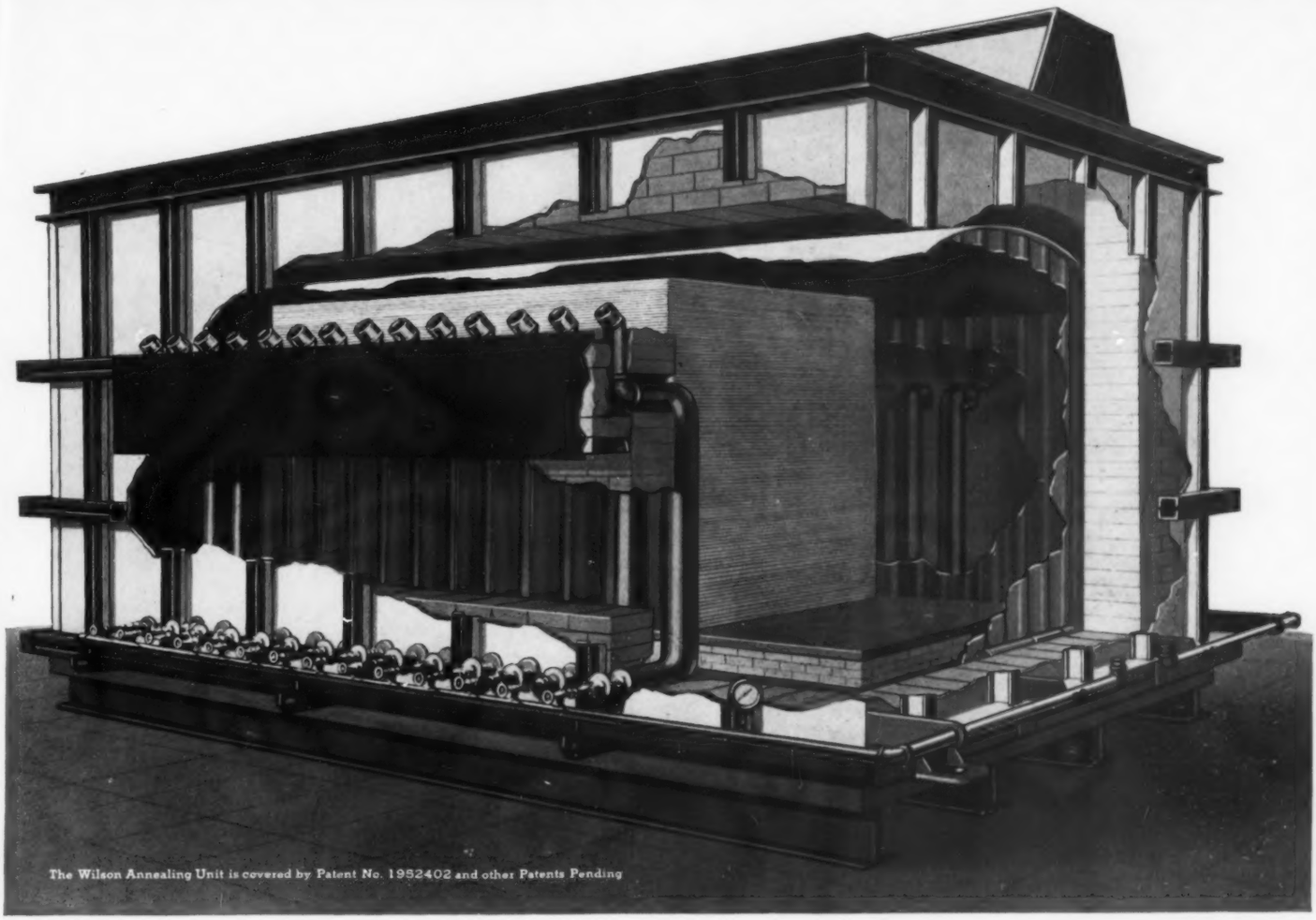
If desired the main line shaft can be removed without dismantling the individual rollers.

The tables are built of steel castings or welded steel construction to meet the customer's requirements.

All gears are totally enclosed and run in oil. Gear covers and inspection holes are very accessible. Arranged for pressure lubrication on all bearings.

LEWIS FOUNDRY & MACHINE CO.
PITTSBURGH, PA.

VERTICAL TUBES
FOR BETTER ANNEALING



The Wilson Annealing Unit is covered by Patent No. 1952402 and other Patents Pending

ONLY with the WILSON VERTICAL RADIANT TUBE ANNEALING FURNACE is it possible to adjust the effective heating length of the furnace to the length of the charge. The illustration above shows how this is done.

Note how overheating of the ends of a short charge is eliminated by shutting off the unnecessary tubes.

With the combination of SINGLE TUBE CONTROL and VERTICAL TUBE design, perfect heat distribution is applied to the bottom of the charge. The temperature then tapers off to give an even heating throughout the whole charge.

RESULT—uniform annealing with a 20 per cent saving in annealing time.

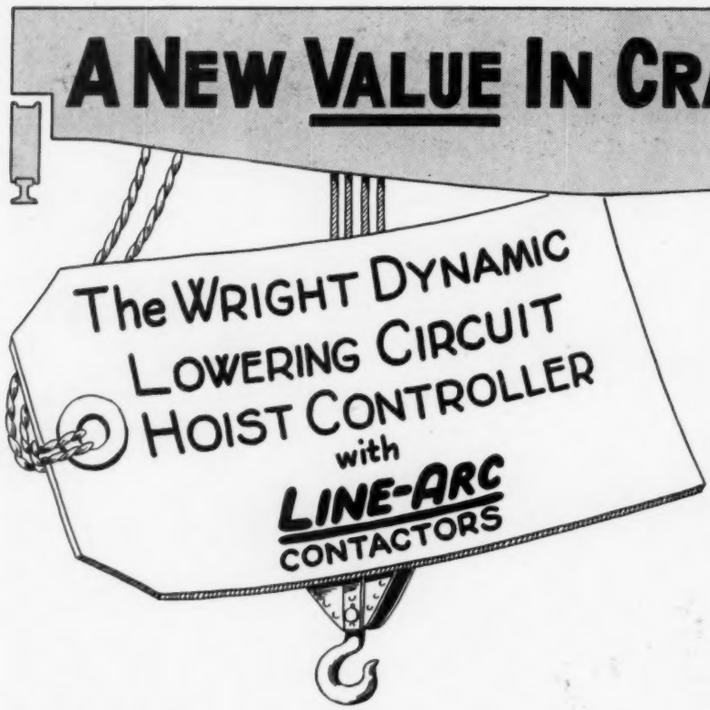
An Exclusive Development of

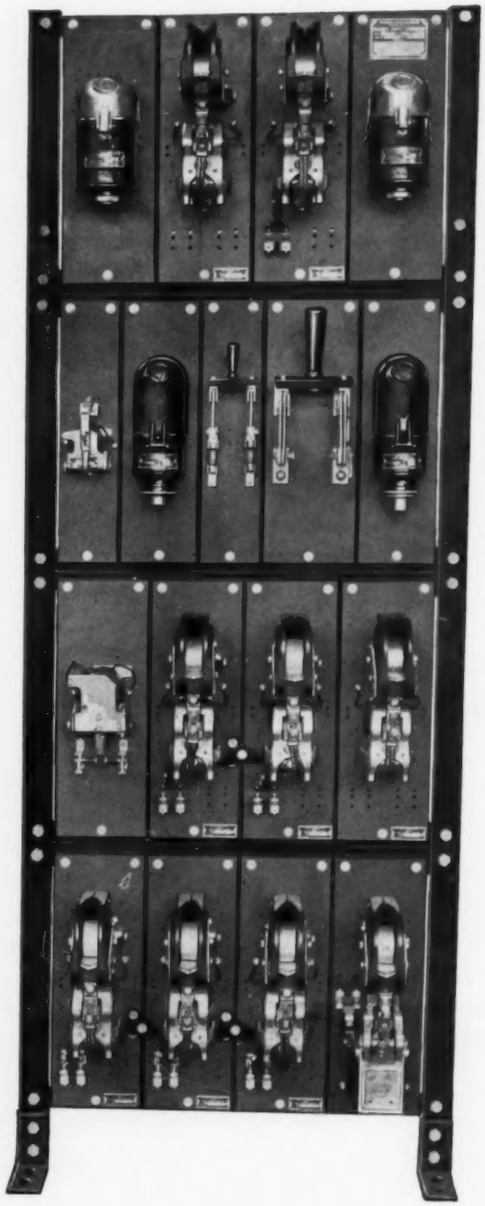
LEE WILSON ENGINEERING CO.

1370 Blount Street • Cleveland, Ohio

SOLD BY THE WEAN ENGINEERING CO., INC., WARREN, OHIO

A NEW VALUE IN CRANE CONTROL





MORE Trips per minute with Less Power Consumption—that has been the guarantee of this hoist controller ever since its announcement over 5 years ago and now to this has been added—SCIENTIFIC CONTROL of the ARC by means of the latest EC&M development—LINE-ARC Magnetic Contactors.

Through this major improvement in magnetic contactor design, not only is crane performance maintained at an outstandingly high standard, but controller performance has likewise been improved and perfected beyond any previous conception, because the arc is scientifically controlled.

On each and every point of the controller, the arc is instantly removed from the contact tips—before the contacts have separated 1/8". This means that contacts operate COOL; under normal conditions, they never even reach the temperature at which the copper will soften. Another contributing factor to long life is that these contacts are made by a special forging process which has greatly increased their resistance to wear.

These new controllers are an outstanding value for cranes and hoists. The next time you buy new cranes or revamp old ones, we suggest you requisition these controllers and test them under your own operating conditions. You'll find they will outperform and outlast all previous designs.

Specify LINE-ARC Magnetic Contactor Control

THE ELECTRIC CONTROLLER & MFG. CO.

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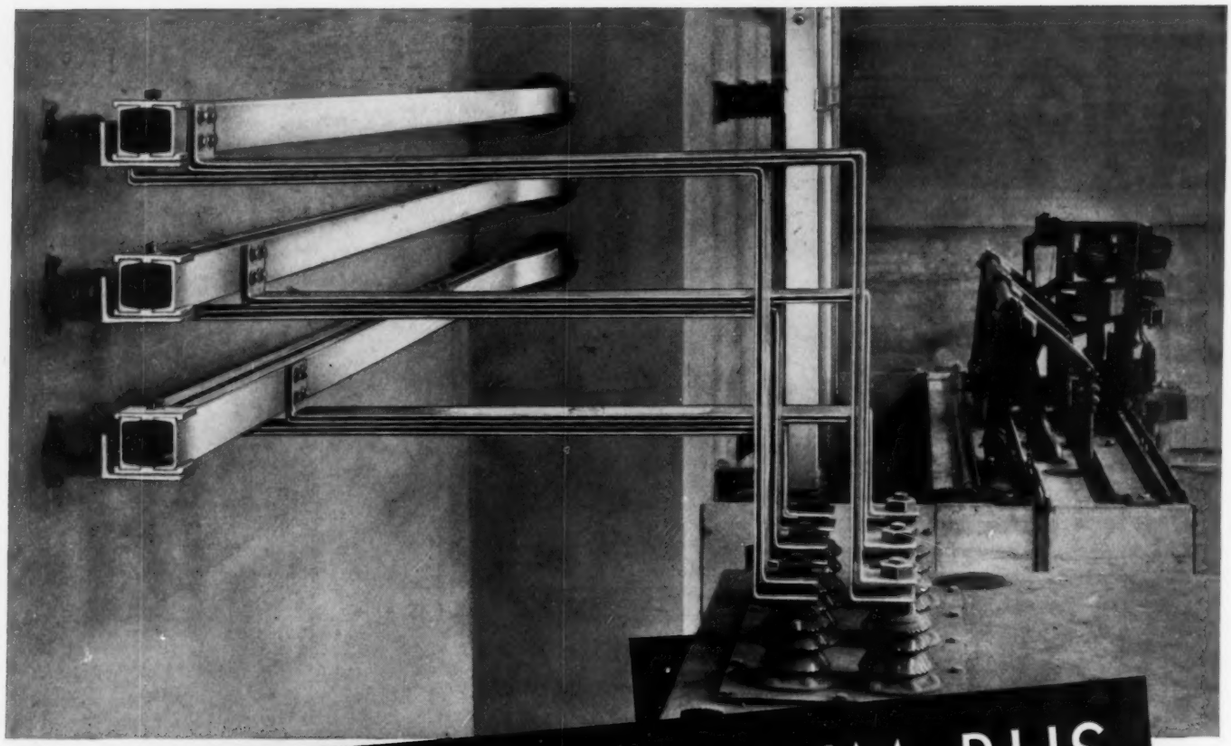
SAN FRANCISCO-420 MARKET ST.
LOS ANGELES-912 E. THIRD ST.
BUFFALO-888 COLVIN BLVD.
SEATTLE-2207-1ST AVE. SO.

HOT STRIP MILLS
and COMPLETE
AUXILIARY FINISHING EQUIPMENT
MESTA
38" HOT STRIP MILL
38" HOT STRIP MILL
79" HOT STRIP MILL
MESTA MACHINE COMPANY · PITTSBURGH



ALCOA ALUMINUM BUS
is dollars and sense Economy

● If you are really serious about saving money on your bus system, and at the same time getting the best installation that money can buy, specify Alcoa Aluminum.

The *per-foot* cost of the bus itself is *very* reasonable, whether your system demands the extra-heavy current carrying capacity of Channeluminum, or the more traditional flat or tubular shapes.

Aluminum Bus weighs at least 52% less. Its strength-weight ratio is high. That means definite cash savings in supporting structure. Often it is possible to locate the run on existing supports where other types of bus would be too heavy.

Lightness means easy handling, quicker erection. Aluminum is easy to work. Joints may be either bolted or welded. Either technique is fast, workmanlike, and permanently efficient. Fittings are simple and inexpensive.

All these facts add up to one thing: Alcoa Aluminum Bus will save you money. We have the details, the data. They are yours for the asking. ALUMINUM COMPANY OF AMERICA, 1828 Gulf Building, Pittsburgh, Pa.

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FROM TOP to BOTTOM
FROM END to END

HORIZONTAL RADIANT TUBE ANNEALING COVERS

provide more definite heat control and other advantages that are facts! These advantages prove why SC Covers give higher quality annealing at lower cost per ton of annealed steel.

Surface Combustion Alloy Radiant Tubes have given lowest fuel consumption in annealing sheets, and a tube has never burned out.

Heat is supplied to the horizontal tubes by radiation, the fastest known method of heating. SC Annealing Covers are the only covers using this superior method of firing.

This method of firing provides a more accurate means of heat distribution than is otherwise possible.

With SC Horizontal U Type Radiant Tube heating elements the only limit to the speed at which a charge can be heated is its ability to absorb heat at the allowable temperature head.

For extreme accuracy each bank of tubes is on separate temperature control.

Space is provided for heat circulation beneath the pile as well as around and over it.

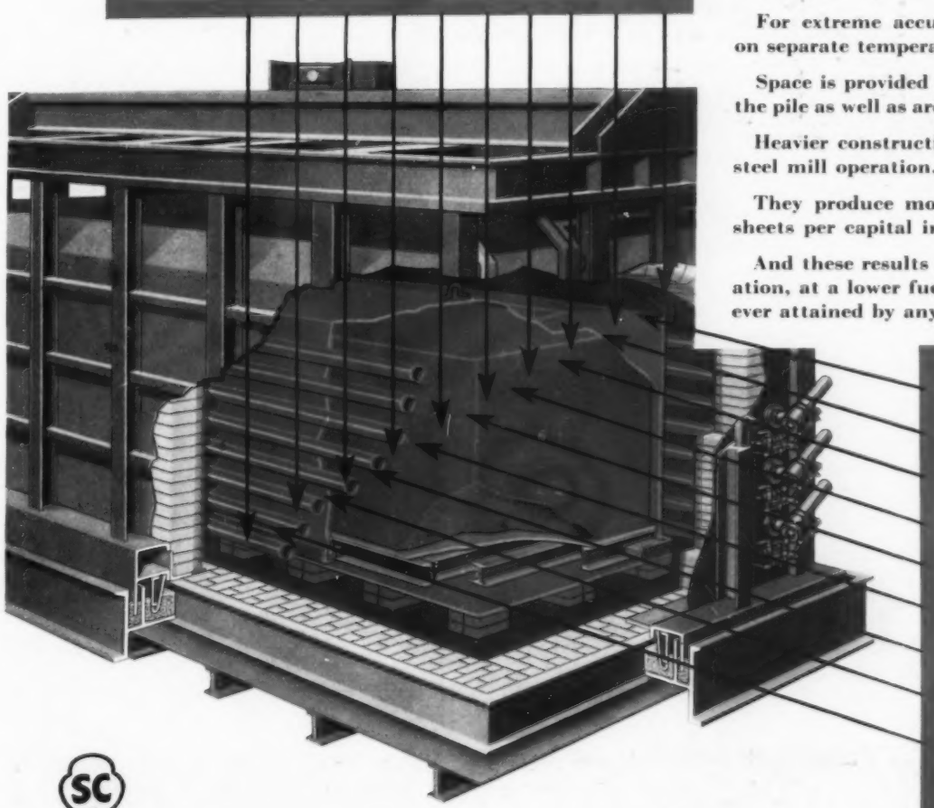
Heavier construction throughout, designed for steel mill operation.

They produce more tons of quality annealed sheets per capital invested.

And these results are produced in actual operation, at a lower fuel consumption per ton than ever attained by any known equipment.

TOP TO BOTTOM

Horizontal Radiant Tube heating elements provide the only method of heating sheets that permits definite control of the amount of heat transferred to the charge from top to bottom. Depending upon the width of the sheets and the height of the pile, more or less fuel, as required, is applied to the upper or lower heating elements. Definite heat control vertically is assured.



END TO END

Definite heat distribution is controlled longitudinally by exhausters on the discharge end of the heating elements. Regardless of the zone, from end to end uniform temperature is easily maintained.

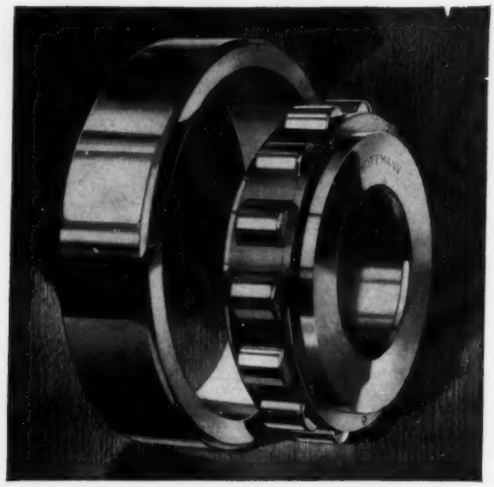
SC

Surface Combustion Corporation

TOLEDO, OHIO

Sales and Engineering Service in Principal Cities

WHERE NO OTHER TYPE OF BEARING WILL



STAND UP

Because of Extreme Load Conditions, Use

PRECISION ROLLER BEARINGS

With the Heavy Bronze Cage

Picture to yourself the most difficult load conditions a bearing can be called upon to meet—high speed, heavy load, temporary overloads, shock, vibration. Then read, in the adjoining column, how NORMA-HOFFMANN Precision Roller Bearings—time-tested heavy-duty units—meet these conditions.

• • •

And remember—PRECISION Roller Bearings interchange in size with all standard ball bearings. They can be had—in addition to the standard type here illustrated—in one-lip, two-lip (self-contained), full roller type (without cage), self-aligning and adapter types.

PARALLEL LINE CONTACT

Solid cylindrical rollers between cylindrical races providing maximum load contact area, increased steady load capacity, and a larger shock-absorbing capacity than any other type of single-row bearing.

SAFETY FACTOR

A margin ample for temporary overloads up to 50% beyond normal rating, as under peak loads, in unusually severe duty, or under shock conditions.

SUPERIOR CAGE

Made of extruded bronze to secure maximum density and uniformity—machined all over for balance—riding on inner ring lands or shoulders, relieving the rolling elements of its weight.

EXTREME ACCURACY

Rollers held to .0001 inch on diameter and to .0002 inch on length, throughout—absolutely true rolling surfaces, ends absolutely square with the sides—highly finished, quiet, friction-free.

DURABILITY

Uniform contact throughout the length of the rollers, providing the most efficient load distribution—greater wear-resisting surfaces—true rolling between all load contact areas—minimum friction between roller and cage.

SPEED QUALITIES

A lower friction coefficient under heavy load than any other type of bearing—a speed ability equal to that of any ball bearing, size for size, up to 35,000 R.P.M.

•

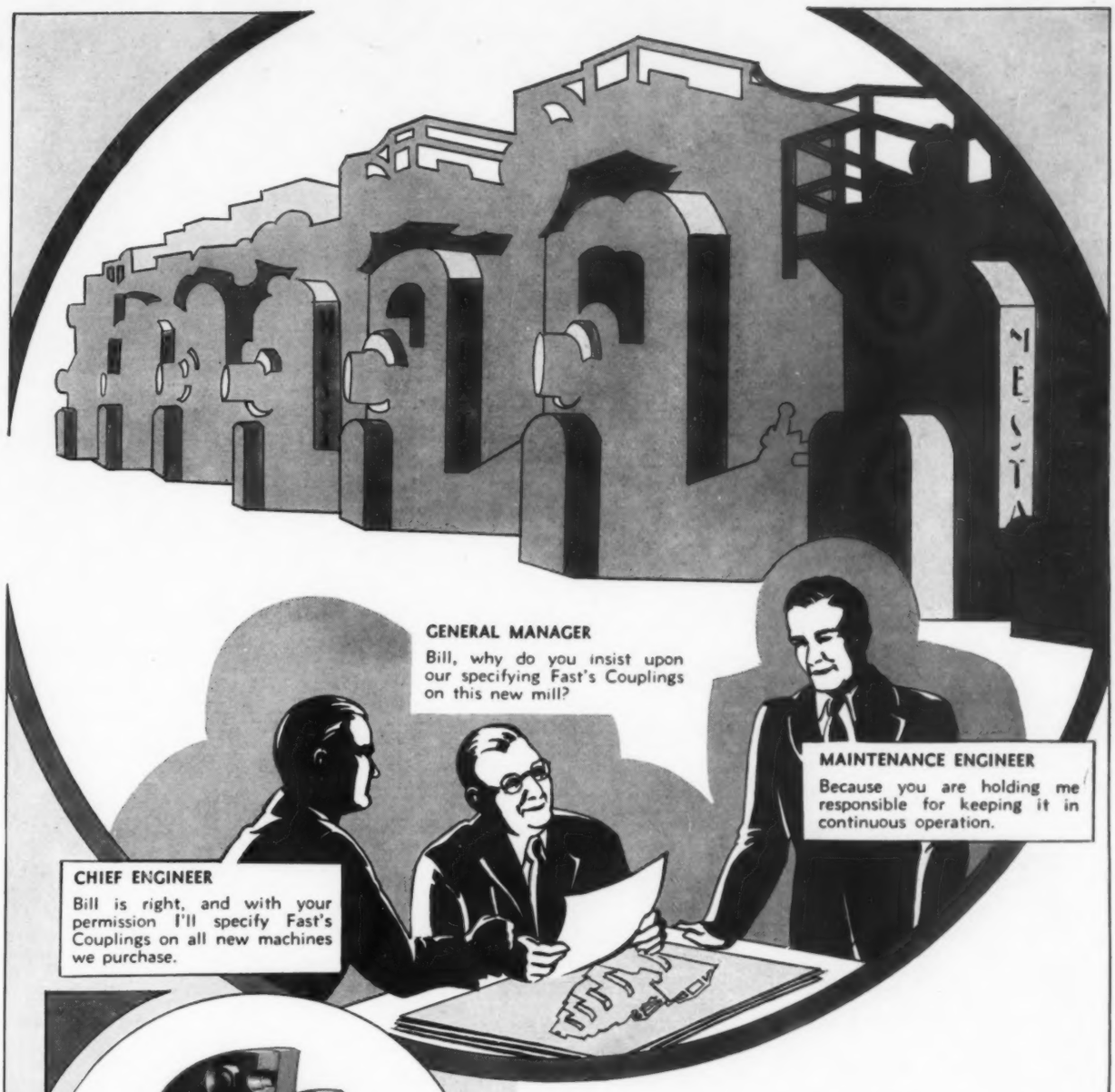
There's no duty too hard for a PRECISION Roller Bearing. And, for the less exacting duties, there are PRECISION Ball and Thrust Bearings. Write for the Catalogs—or ask our engineers for suggestions.

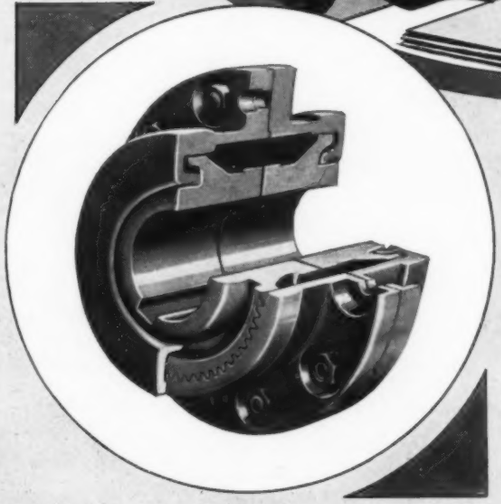
"NORMA-HOFFMANN"

PRECISION BEARINGS

BALL, ROLLER AND THRUST

NORMA-HOFFMANN BEARINGS CORPORATION, STAMFORD, CONN., U. S. A.


GENERAL MANAGER
Bill, why do you insist upon our specifying Fast's Couplings on this new mill?
MAINTENANCE ENGINEER
Because you are holding me responsible for keeping it in continuous operation.
CHIEF ENGINEER
Bill is right, and with your permission I'll specify Fast's Couplings on all new machines we purchase.



The illustration above shows Fast's construction. No perishable materials are necessary to make it dust and moisture proof.

FAST'S PATENTS COVER THESE VITAL FEATURES

ALERT operating men are avoiding troubles by anticipating them. Since Fast's Self-Aligning Couplings were put on the market fifteen years ago, thousands of them have been installed on main rolls and auxiliary drives where they have made an enviable place in steel mill history for dependable, trouble-free operation.

These qualities are built into Fast's Couplings. The only attention they require is oiling. The contact or load carrying surfaces are protected from wear by a film of oil. This oil is kept permanently clean by Fast's rocking bearings which are located in the one position where they will make dust and moisture proof seals.

Specify genuine Fast's Self-Aligning Couplings on all machinery you purchase and avoid operating trouble.

The Bartlett Hayward Company

BALTIMORE, MARYLAND

THE *first basic advance* IN D.C. WELDER DESIGN IN 20 YEARS

THE *New* FLEXARC

HOLDS LONGEST ARC OF ANY WELDER EVER BUILT... *try it!*

WESTINGHOUSE ANNOUNCES A FLEXARC WELDER WITH RADICALLY DIFFERENT PRINCIPLES OF CONSTRUCTION, OPERATION, CONTROL . . . .

1. **New design improves performance . . . removes nuisance-features.**
2. **New type of generator provides steady, blow-out-proof arc—simplifies operation.**
3. **New all-mechanical control takes "cut and try" out of adjustment.**
4. **New voltage feature makes welding safe.**

Since the first arc welding machine went on the market, 20-odd years ago, there had been no change in basic design. Improvements had been made, to be sure. In fact, machines of all makes were so highly perfected *in detail* that their performance limit had apparently been reached.

But four years ago Westinghouse engineers set out to develop an entirely new welder that would out-perform any existing machine—one that would vastly extend the field of arc welding application.

And now Westinghouse announces the New FlexArc. Radically and basically different, both in physical make-up and in performance characteristics. It embodies a new principle of design which is responsible not only for the desired improvement in performance, but also removes certain "nuisance-features" found in conventional machines . . . such as meters, rheostat, exciter, reactor.

A new type of generator provides a steady, blow-out-proof arc. Arc stability now, for the first time, becomes a reality and makes operation so simple that the normal training period for operators is substantially shortened.

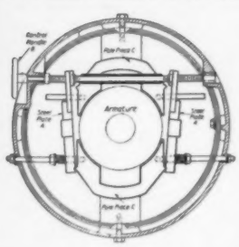
A new all-mechanical control takes the "cut and try" out of adjustment and makes possible a remarkably low open-circuit voltage—always so desirable from the view-point of safety—but retaining all of the desirable arc characteristics usually associated with the high open-circuit voltage indispensable in conventional welders.

ASK FOR A DEMONSTRATION

See and try the new FlexArc. Compare it with any other make. Test it. Study its performance curves and you will see how it renders your present equipment obsolete.

Westinghouse

HERE'S THE SECRET OF ITS PHENOMENAL PERFORMANCE



The diagram shows the all-mechanical principle of control employed in the New FlexArc. Steel plates A are moved in or out by the control handle B. The steel plates, by their distance from the pole pieces C, increase or decrease the magnetic flow between field poles and therefore change the current value of the generator output.

This entirely new principle eliminates such parts as exciter, rheostat, reactor, meters and objectionable features which were necessary on conventional designs to insure good performance.

. . . Easy to buy this GUARANTEED WELDER

Westinghouse Welding Dealers or Sales Offices offer—

- 30-DAY TRIAL
- EASY PAYMENT PLAN
- LIBERAL TRADE-IN ALLOWANCE

FIRST WELDER EVER SOLD WITH THIS 6-POINT GUARANTEE

THE NEW FLEXARC WELDER IS GUARANTEED TO GIVE THE USER—

1. LOWER COST WELDS 2. FASTER WELDS 3. MORE ELECTRODE DEPOSIT 4. STRONGER, DENSER WELDS 5. LOWER UPKEEP EASIER OPERATION

Westinghouse Electric & Mfg. Co.
Room 3-N East Pittsburgh, Pa.

Gentlemen:—I want the whole story on your new FlexArc Welder. Send me the following:

- ☐ Descriptive Booklet
- ☐ Details of 30-day Trial Offer
- ☐ Details about Easy Payment Plan and Trade-in Allowance

Name .....

Position .....

Company ..... 1 & SE 12-38

Address .....

DELTABESTON STATION CABLE

Defies Severe Operating Conditions

Glaring heat, stifling humidity — twin enemies of electric cables — are powerless to damage Deltabeston felted asbestos insulation. It forms a solid, flexible tube of intertangled, impregnated asbestos fibres which cannot be unraveled or unwound.

For installations which must withstand as much as 400° F. use Deltabeston Station Cable insulated with two layers of felted asbestos with Glyptal coated cloth inserted in between. Other types of Deltabeston Station Cable are available for use where voltages are lower or operating conditions less severe — all with insulation of genuine Deltabeston felted asbestos.

Write to Section Y-2912, Merchandise Department, General Electric Company, Bridgeport, Connecticut for further information about sizes and types to meet your specific requirements.

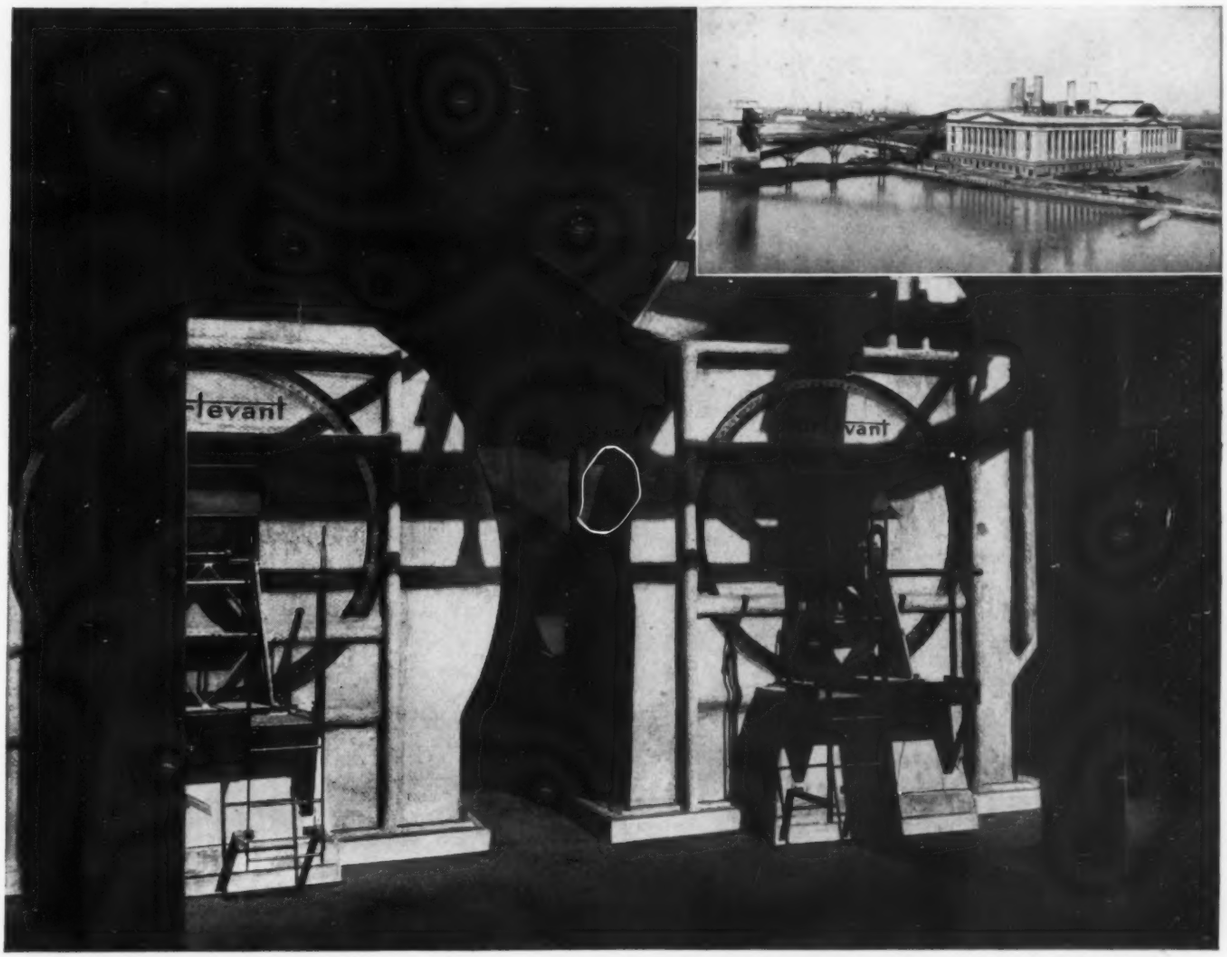
GENERAL ELECTRIC

DELTABESTON

MERCHANDISE DEPARTMENT, GENERAL ELECTRIC COMPANY, BRIDGEPORT, CONNECTICUT

STURTEVANT INDUCED DRAFT FANS CHOSEN FOR 165,000 K.W. ADDITION

. . . TO RICHMOND STATION—PHILADELPHIA ELECTRIC CO.



Showing two of four Sturtevant Turbovane Induced Draft Fans, each rated 190,000 c.f.m., recently installed for 165,000 k.w. addition to Richmond Station of Philadelphia Electric Company. Addition designed and constructed by United Engineers and Constructors, Inc. in cooperation with engineers of Philadelphia Electric Company.

HIGH EFFICIENCY, reliable operation and rugged construction were the most essential requirements in selecting equipment...when Philadelphia Electric Company recently doubled the capacity of their Richmond Station. 165,000 K.W. capacity was installed in space originally provided to accommodate 50,000!

For induced draft, primary air, and pulverized coal mill service, the engineers chose 12 Sturtevant Turbovane Fans.

The four Sturtevant self-cleaning Induced Draft Fans are each rated 190,000 c.f.m. at 380°F. against 14.5 static pressure. Speed: 850 R.P.M. They serve two new Babcock & Wilcox 600,000 lb. per hour pulverized-coal-fired boilers.

Primary air fans (4) each have a capacity of 22,000 c.f.m. The four mill exhausters are each rated 13,000 c.f.m.

B. F. STURTEVANT CO., Hyde Park, Boston, Mass.
New York, N.Y., 420 Lexington Ave. Chicago, Ill., 400 N. Michigan Ave.
San Francisco, Cal., 681 Market St. *Branch Offices in Other Cities*

Sturtevant
REG. U.S. PAT. OFF.

DRAFT FANS · TURBINES · GEARS · ECONOMIZERS · AIR HEATERS

HOW EASILY CLEANED?

. . A Vital Question on Fuses

CASING SMOOTH AS A GUN BARREL

SIMPLE

Note the few parts of a Jefferson-Union Fuse—knife-blade type above, ferrule type below. The fewer the parts, the more rugged and the better they can be—and the less time lost in renewing.

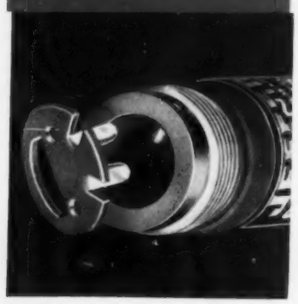
FAILING to clean thoroughly the casing of a renewable fuse shortens its useful life. An easy job to do is apt to be done—and done thoroughly.

There are no obstructions to cleaning in a JEFFERSON-UNION casing. The volatilized metal can be removed—easily, quickly. The fibre used is the strongest and toughest that long experience has found. And the fusible link is designed to reduce the amount of metal volatilized to a minimum. Misaligned or twisted fusible elements—another cause of ruined fuses—are avoided with JEFFERSON-UNION FUSES. They cannot be assembled wrong.

For these reasons many renewals, minimum yearly fuse costs are assured by JEFFERSON-UNION RENEWABLE FUSES.

ALIGNED AUTOMATICALLY

Cannot be assembled wrong. Prongs on collar of knife-blade link assembly must lie in slots before fuse will assemble. Ferrule type link (below) is aligned by washer with prongs which must fit over aligning pin.

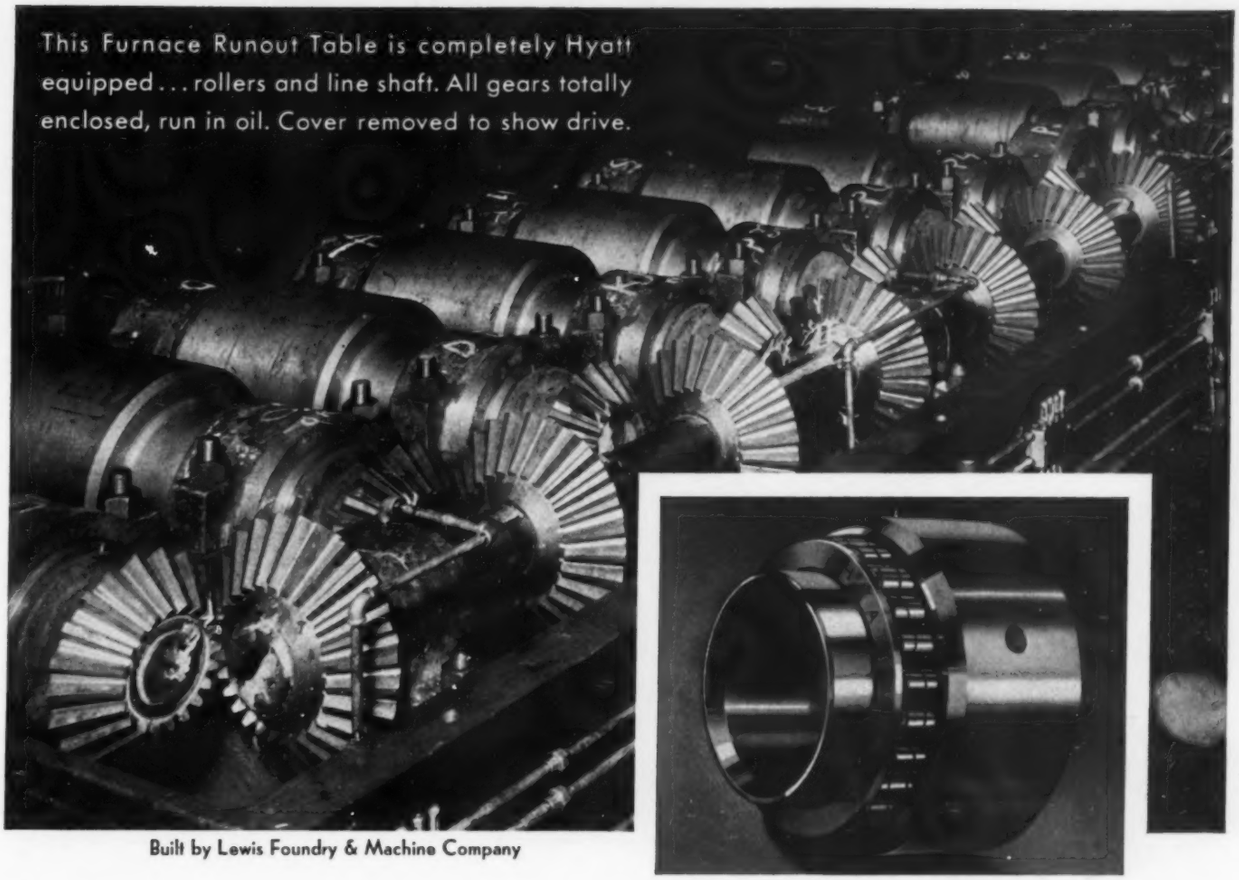


JEFFERSON ELECTRIC CO.

Bellwood (Suburb of Chicago) Illinois
Canadian Factory: 535 College St., Toronto.

JEFFERSON UNION

Renewable FUSES


This Furnace Runout Table is completely Hyatt equipped . . . rollers and line shaft. All gears totally enclosed, run in oil. Cover removed to show drive.

Built by Lewis Foundry & Machine Company

Year after Year . . . *More and More* HYATTS

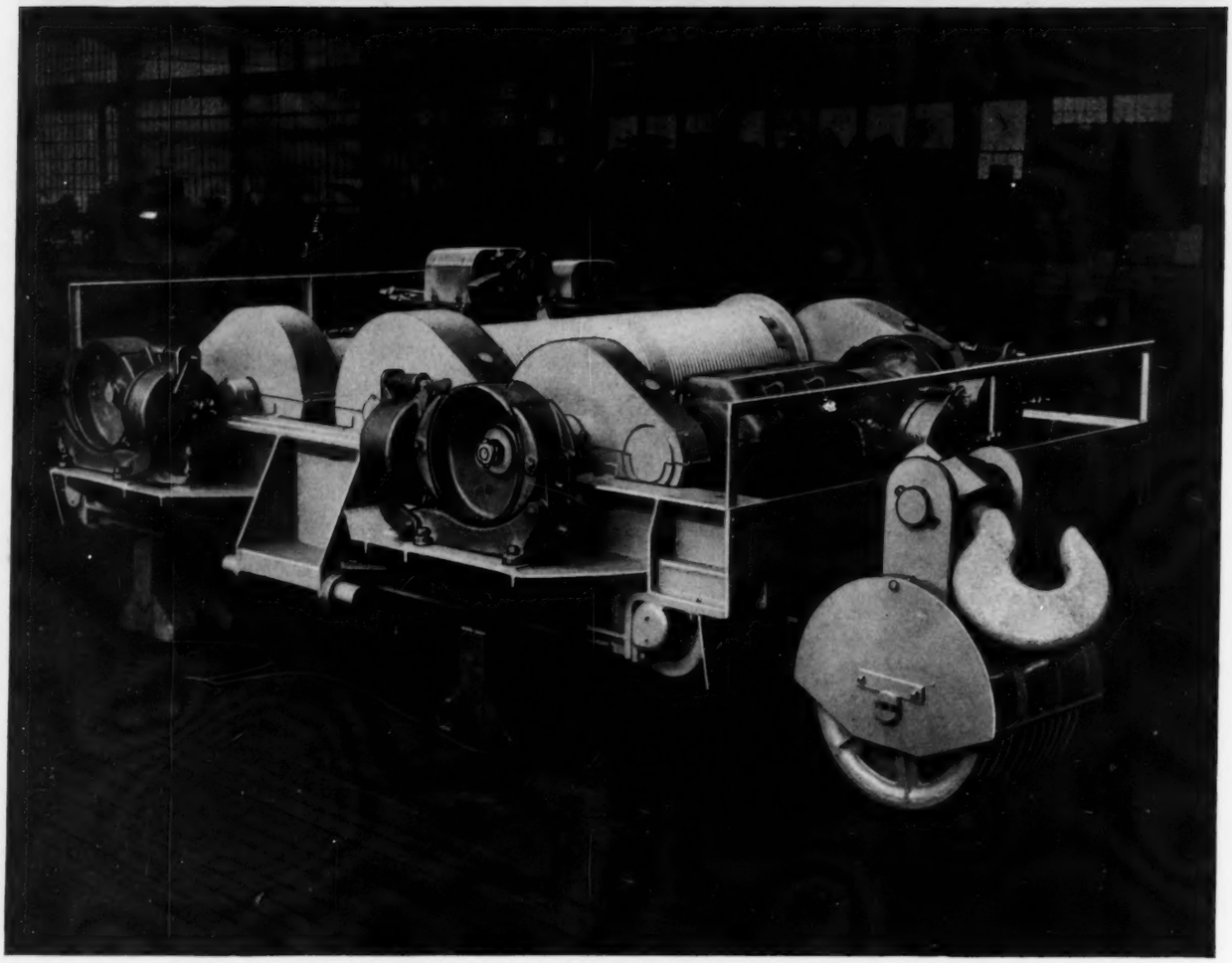
Each year equipment is operated faster and harder . . . and each year finds more and more Hyatt Roller Bearings carrying the load. Dependable bearings that operate with utmost efficiency. Precision bearings, which equipment builders know measure up to the excellence of their own design. That is why equipment builders use Hyatts so generously and why the purchaser of this equipment places such confidence in Hyatt applications. Hyatt Roller Bearing Company, Newark, Detroit, Chicago, Pittsburgh, San Francisco.

H Y A T T

ROLLER BEARINGS

PRODUCT OF GENERAL MOTORS

DO YOUR OLD CRANES NEED NEW TROLLEYS?



A 60 Ton Mill Type Trolley, all welded

one piece frame, Roller Bearings throughout

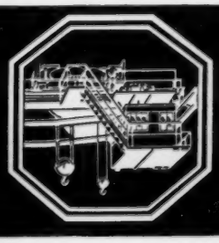
●

5200 Cranes have been built by Cleveland in 35 years. This well fits us to meet your most exacting modernizing requirements.

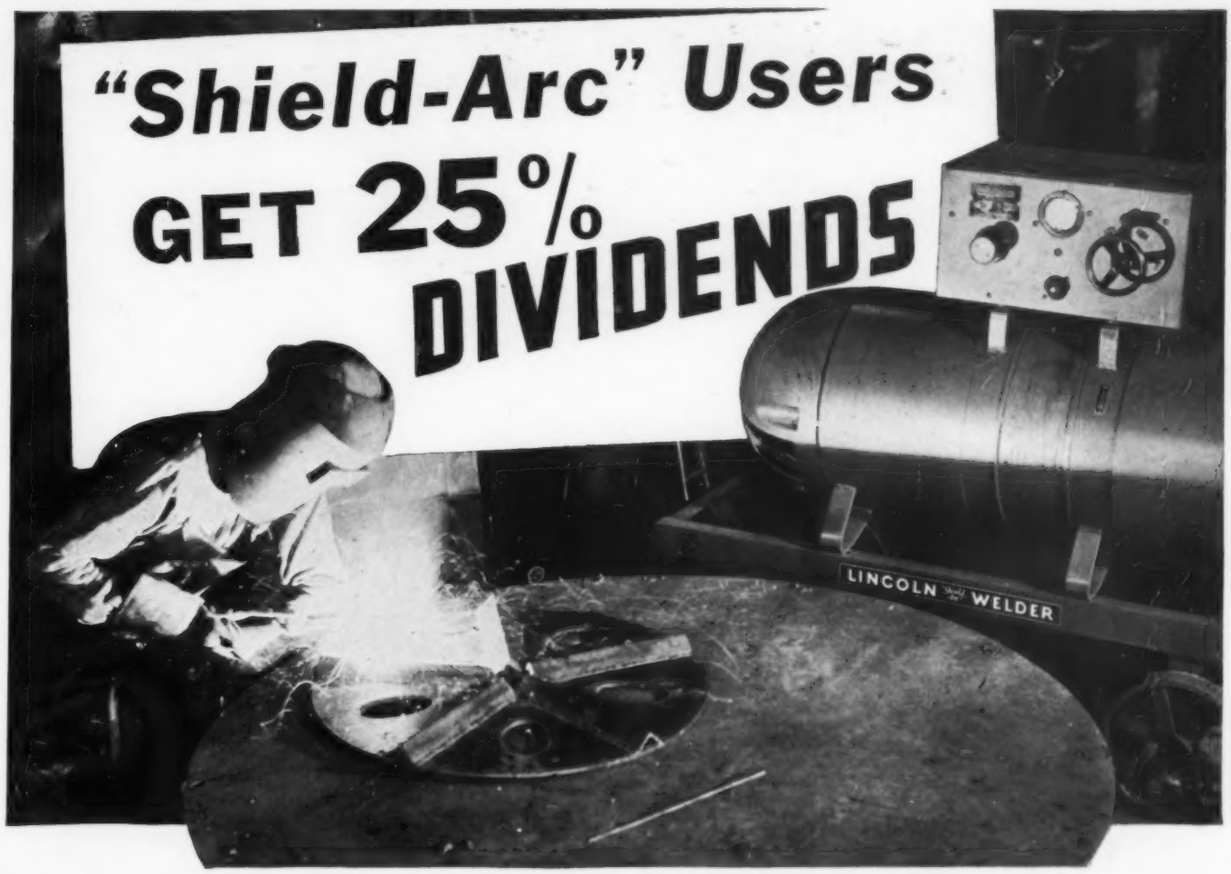
• Custom built or standard equipment •

THE CLEVELAND CRANE & ENGINEERING CO

NEW YORK DETROIT WICKLIFFE, OHIO PITTSBURG CHICAGO

CLEVELAND  CRANES

"Shield-Arc" Users GET 25% DIVIDENDS



Yes, it's true, the new easily-operated "*Shield-Arc*" welder actually gives you 25% more welding per dollar than ordinary welders. "*Shield-Arc's*" greater weld production per dollar insures profits in two ways: You can weld as much as with present equipment and save 25 cents on the dollar; or you can spend the whole dollar and get an extra 25 cents worth of welding *free!*

These savings are yours with "*Shield-Arc*" because with "*Shield-Arc*" you have every feature vital to lowest possible welding costs.

"*Shield-Arc's*" more uniform current keeps down splatter and waste of molten electrode metal, puts more metal into the weld.

"*Shield-Arc's*" higher capacity lets you use larger size electrodes. By jumping just one size electrode, you can save up to 25% on welding costs.

"*Shield-Arc's*" increased efficiency lets you save on power costs, gives you more welding per kilowatt hour.

And "*Shield-Arc's*" remote control—the amazing device that permits current adjustment at the work—saves up to $500 per year per welder.

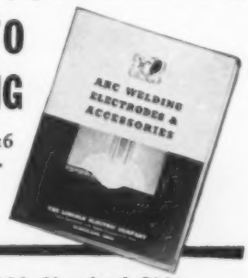
These and other welding cost-cutting features make the "*Shield-Arc*" today's most economical welder. Why not find out about it now? Address THE LINCOLN ELECTRIC COMPANY, Dept. Z-189, CLEVELAND, OHIO. Largest Manufacturers of Arc Welding Equipment in the World.

POP: "Imagine that welding foreman saying we'd be money ahead if we scrapped the old arc welder. Why, it doesn't make sense!"

LAD: "What you mean is, the old welder doesn't make cents. Compared with the new '*Shield-Arc*', it wastes 25 cents out of every dollar we spend on welding."

FREE NEW GUIDE TO BETTER WELDING

Complete descriptions, applications and procedures on 16 Lincoln electrodes. Pictures of all latest welding accessories. Every user of arc welding needs this book. Helps you do better work and get the most out of arc welding. Send the coupon today. No obligation.



THE LINCOLN ELECTRIC COMPANY, Dept. Z-189, Cleveland, Ohio

Gentlemen: Please send me (without obligation) the new Guide to Better Welding. I now weld with (check which) electric arc ☐ gas ☐ none ☐.

Firm Name _____

Your Name _____ Title _____

Address _____

City _____ State _____

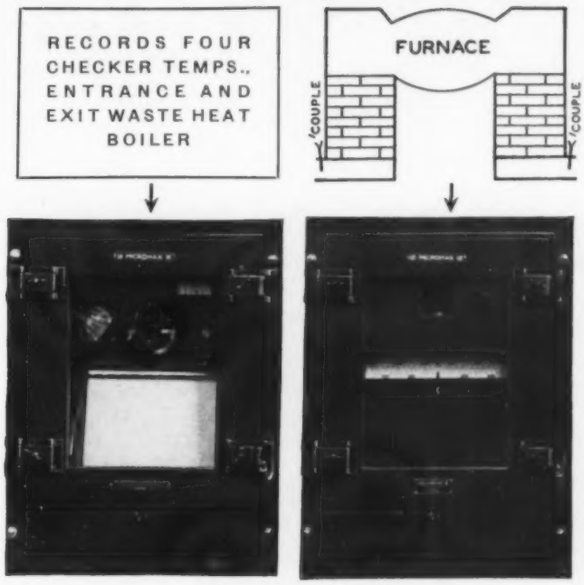
Isn't this

Horse Sense?

When "Tool Steel" gears, wheels, etc.
are showing good profits in your department,
why not tell others in your plant
so the whole company benefits?

REVERSAL CONTROL ALONE

For TOP VALUE FROM REGENERATORS



To get top value from regenerators, the system must be reversed: (1) when reversal will return most heat; (2) without needless loss of time. When the furnace operator reverses before or after best reversal conditions are reached, fuel is wasted and heating time lengthened. When prevented, either by other duties or by the delays of manual adjustment, from reversing in the shortest possible time, fuel is wasted for each second lost—seconds that become expensive hours in a year's time.

These wastes are stopped by L&N Automatic Temperature-Difference Reversal—a simple, rugged control that reverses in response to difference in temperature between the two ends of the furnace.

Reversals throughout the campaign are made only when reversal will be most advantageous.

The operator sets the temperature-difference, and changes it at will, by turning a knob. He can shorten the time between reversals, without upsetting the heat balance, by simply narrowing the temperature-difference limits to which the Controller is set. During hot repairs or charging, he can switch off the automatic control and reverse from a push-button station.

J-643(3)

LEEDS & NORTHRUP COMPANY
4942 STENTON AVENUE PHILADELPHIA, PA.

LEEDS & NORTHRUP

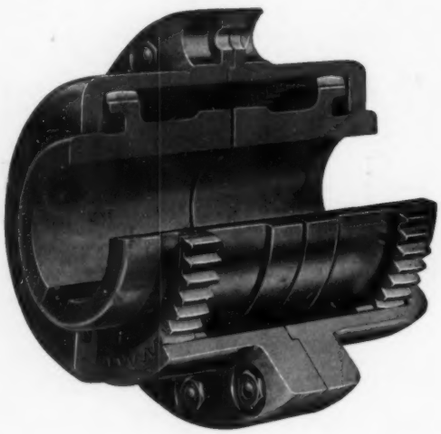
MEASURING INSTRUMENTS, TELEMETERS AND AUTOMATIC CONTROLS

L&N OPEN-HEARTH CONTROL SYSTEM
COMBUSTION — PRESSURE — REVERSAL — ROOF TEMPERATURE

Specifying

Poole FLEXIBLE Couplings

Safeguards Your Equipment Against Wear, Breakdowns and Costly Maintenance



•

The gear type coupling with more superior points, scientifically designed, than any other similar type.

•

Forged Steel---No Fatiguing Parts
Fully Lubricated --- Dust Proof
Self Aligning Without Binding

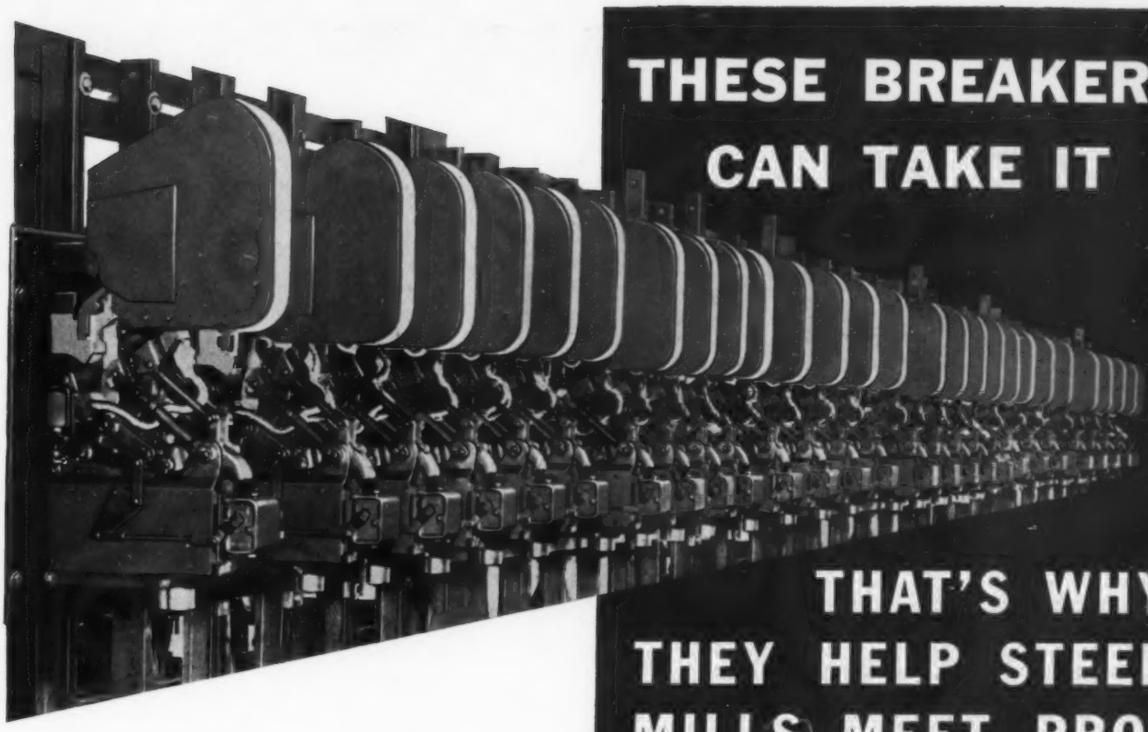
Get the facts about POOLE couplings by sending for our handbook,

"FLEXIBLE COUPLINGS"

Free for the asking—Get it today.

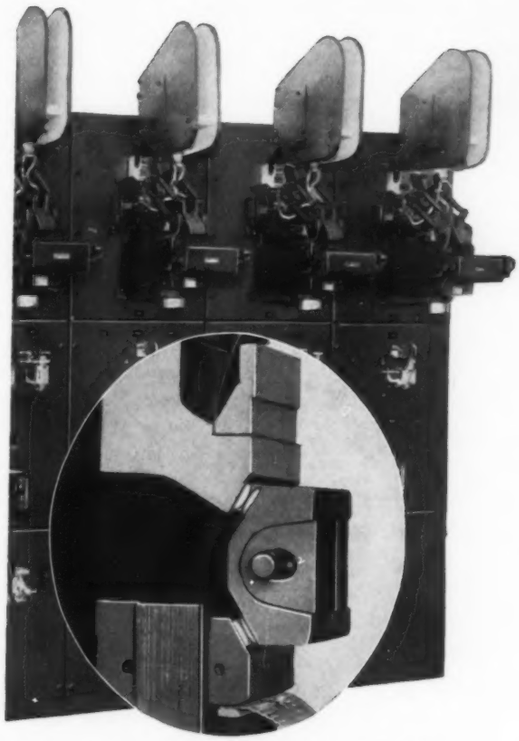
Poole Foundry & Machine Company

Baltimore, Maryland



THESE BREAKERS CAN TAKE IT

THAT'S WHY THEY HELP STEEL MILLS MEET PRODUCTION SCHEDULES



Silver-to-silver solid-block main contacts, with ability to withstand repeated pounding

THESE Type MC-5 air circuit breakers are part of a recent shipment of more than 35 panels to one steel mill.

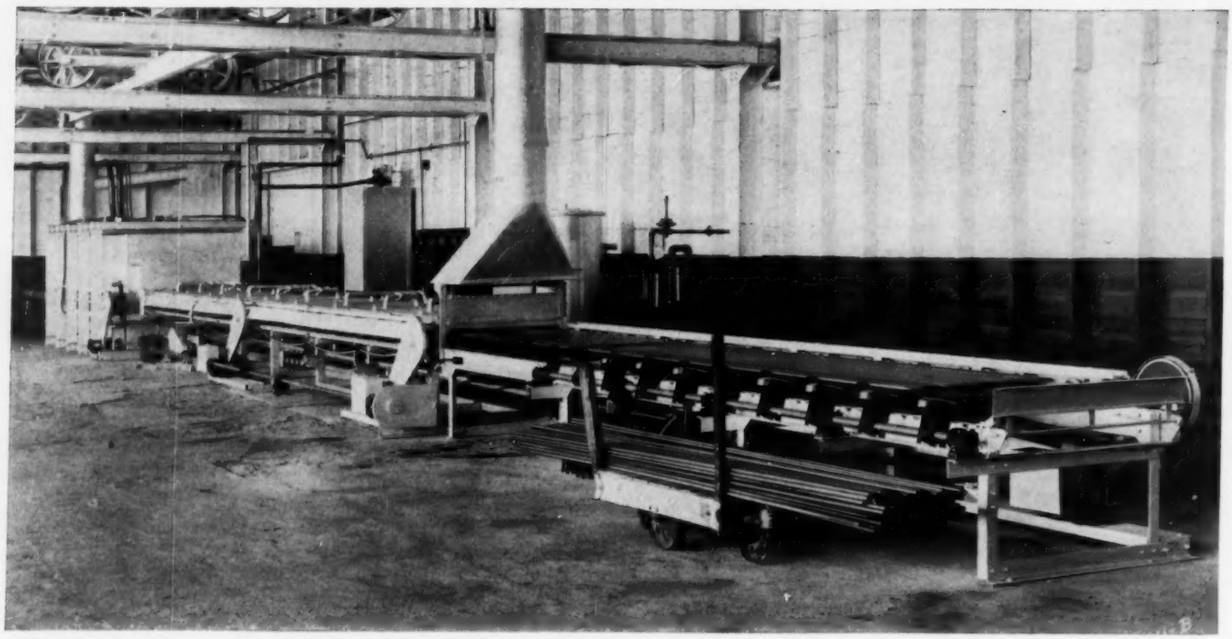
MC-5 equipments have been selected for the main-drive 600-volt d-c buses on two of the latest and largest hot-strip mills.

MC-5 equipments were selected for five out of six of the most recent large steel-mill installations. These have the distinctive G-E structural bus assembly* for important 250-volt d-c mill-auxiliary service. General Electric, Schenectady, N.Y.

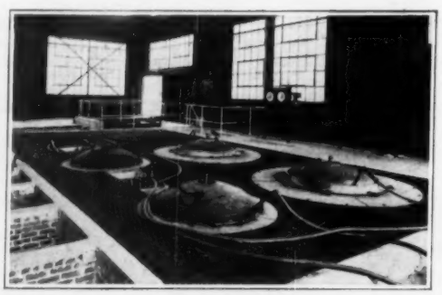
*Buses and extended connections of massive structural shapes on extra-heavy porcelain insulators, all heavily reinforced for short-circuit stresses.

860-12

GENERAL ELECTRIC

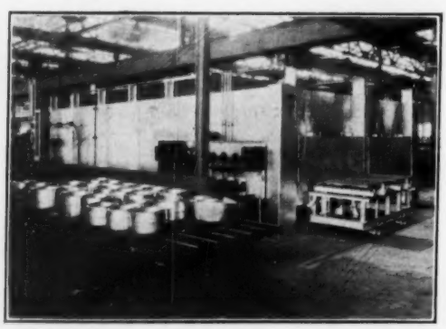


BRIGHT ANNEALING STEEL TUBING —CONTINUOUSLY



Bright Annealing Wire

Pit type furnaces for bright annealing steel wire and for clean normalizing and spheroidizing rod. Advantages include— increased tonnage per pit, improved fuel economy and more uniformly annealed product. Send for furt her information.



Bright Annealing Strip

Ferrous and non-ferrous strip is economically and uniformly annealed in coils and strip form in continuous and recuperative type furnaces we have built. A recuperative furnace for this purpose is shown above. Additional information gladly furnished.

Steel tubing in various lengths is bright annealed—continuously—in the controlled atmosphere, conveyor type furnace shown above.

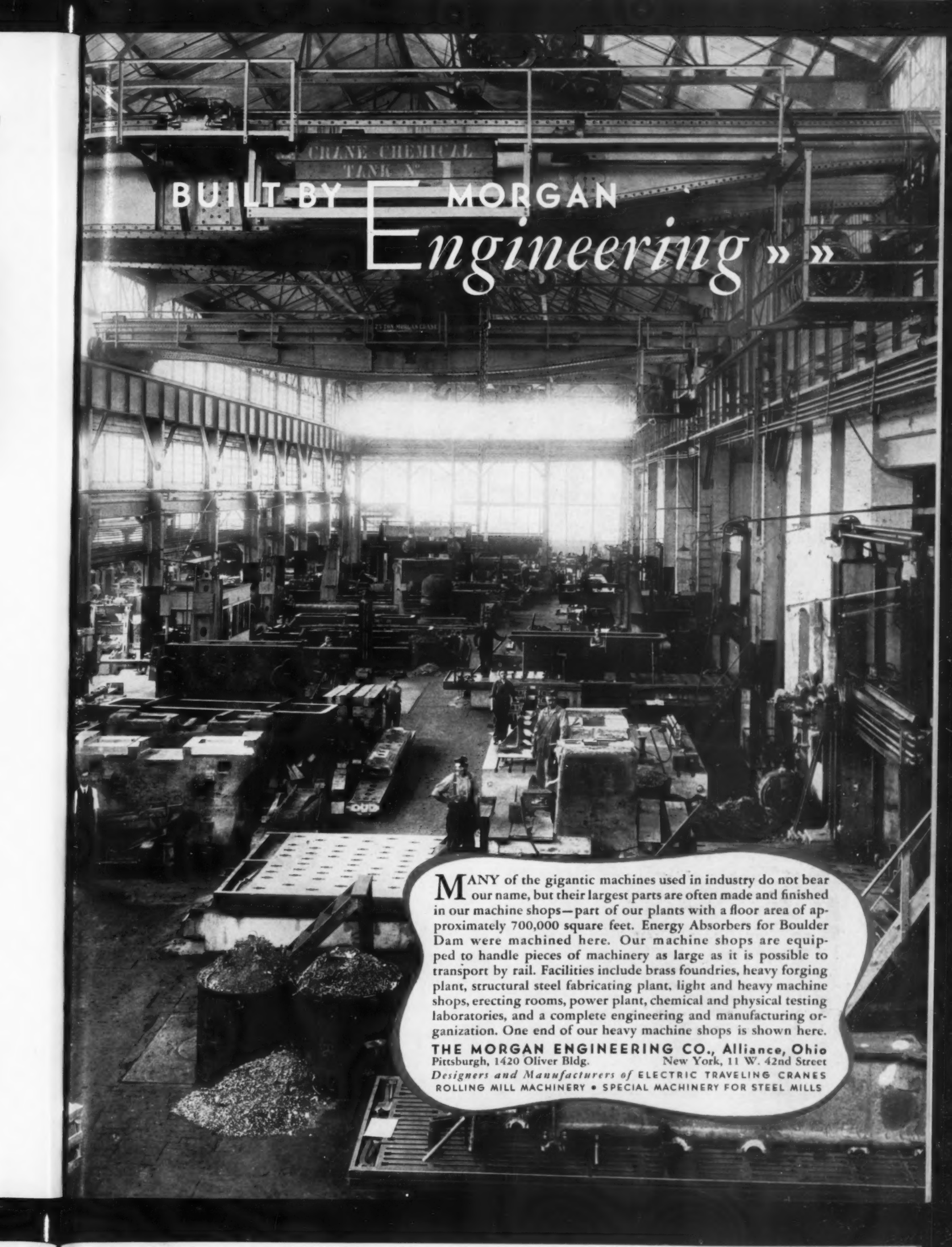
The tubing is loaded on a conveyor at the far end of the furnace and without further attention is conveyed through the heating and cooling chambers in a special atmosphere; discharged onto an unloading table and automatically unloaded onto trucks. The Elfurno generator for supplying the special atmosphere is shown in the background.

The above furnace has capacity for bright annealing 40,000 lbs. of tubing per day but can be built in larger or smaller sizes. We have also made several outstanding installations for bright annealing non-ferrous tubing in coils and straight lengths. Additional information gladly furnished on request.

We specialize on building electric and fuel-fired furnaces to fit the customer's specific requirements, for any heating or heat treating process, for any product or production. No job is too large or unusual. We solicit your inquiries.

THE ELECTRIC FURNACE CO.

Fuel Fired Furnaces — SALEM, OHIO — Electric Furnaces



MANY of the gigantic machines used in industry do not bear our name, but their largest parts are often made and finished in our machine shops—part of our plants with a floor area of approximately 700,000 square feet. Energy Absorbers for Boulder Dam were machined here. Our machine shops are equipped to handle pieces of machinery as large as it is possible to transport by rail. Facilities include brass foundries, heavy forging plant, structural steel fabricating plant, light and heavy machine shops, erecting rooms, power plant, chemical and physical testing laboratories, and a complete engineering and manufacturing organization. One end of our heavy machine shops is shown here.

THE MORGAN ENGINEERING CO., Alliance, Ohio
Pittsburgh, 1420 Oliver Bldg. New York, 11 W. 42nd Street
Designers and Manufacturers of ELECTRIC TRAVELING CRANES
ROLLING MILL MACHINERY • SPECIAL MACHINERY FOR STEEL MILLS

RELIANCE GEARMOTORS TO MEET *Every Situation*

At the left—Standard open type squirrel-cage double-reduction Gearmotor for alternating current.

A LOGICAL development, this idea of combining motor and speed reducer into one self-contained, protected unit. As the illustration shows, Reliance offers a range of types and styles so wide as to make possible the choice of the *one best* installation to fit every case. Reliance's conception of gearmotor design demands a marked simplicity, ruggedness, adequate support at all points, ease of taking apart and assembling and quiet operation. You get lower initial cost, low installation cost, low maintenance cost—and longer, uninterrupted service.

RELIANCE ELECTRIC & ENGINEERING CO.
1088 Ivanhoe Road Cleveland, Ohio

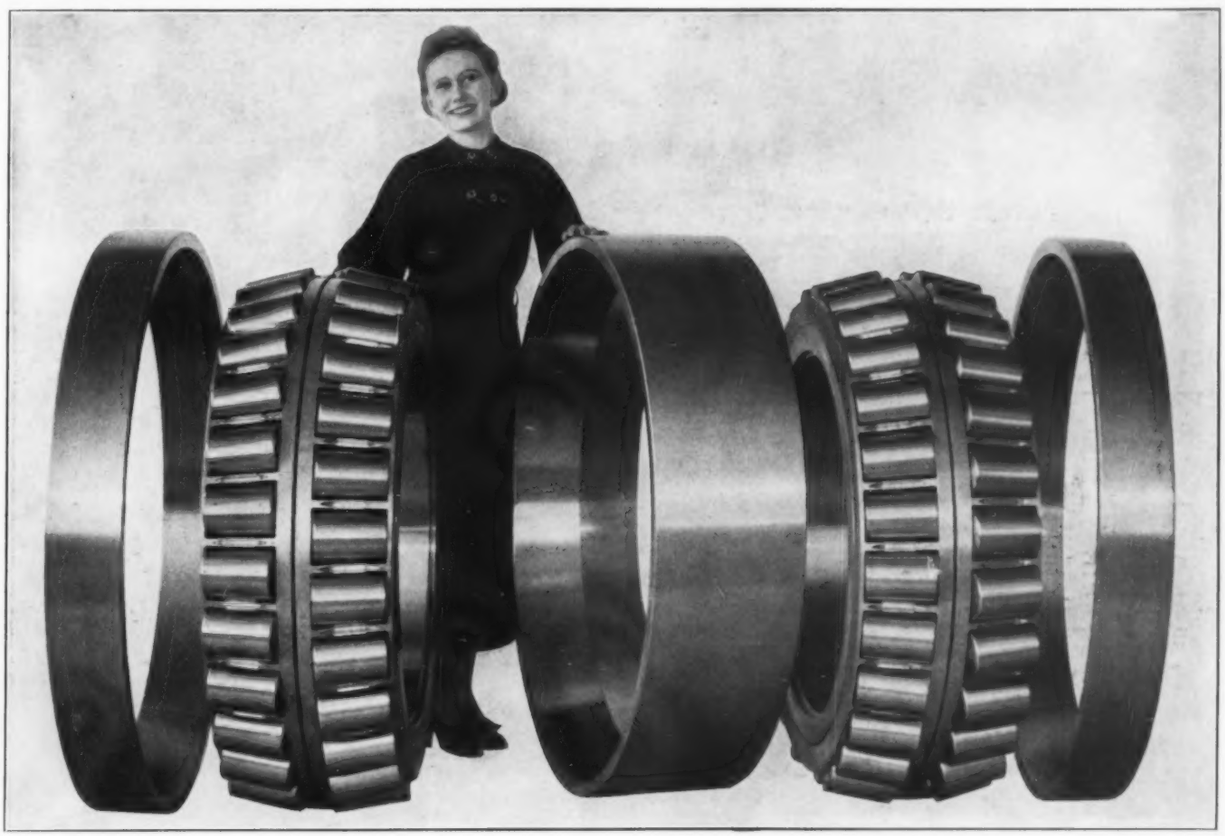
Branches: Birmingham, Boston, Buffalo, Chicago, Cincinnati, Detroit, New York, Philadelphia, Pittsburgh

Representatives in other principal cities.

RELIANCE A-C D-C MOTORS

BANTAM

SPECIFIED 100%



Eight of these Bantam Bearings—29½" I.D. x 44½" O.D. x 27" long—were specified on two 4-Hi 84" Cold Mills built by E. W. Bliss Co. Work rolls were also equipped with Bantam Bearings.

Take your Toughest Bearing job to Bantam

Send for new general catalog on Ball and Roller Bearings.

Trade Mark Reg. U.S. Pat. Off.

BBB

THE BANTAM BALL BEARING CO.

SOUTH BEND, INDIANA

CHICAGO DETROIT HARTFORD MILWAUKEE NEW YORK PHILADELPHIA SEATTLE
NEW ORLEANS PITTSBURGH ROCHESTER, N. Y. TOLEDO WASHINGTON, D.C. YOUNGSTOWN

ONE OR A HUNDRED MILLION • 1/32" TO 60"

HELWIG SPEER

CARBON BRUSHES

A complete line of carbon products correctly engineered for the job. Special brushes designed to suit your purpose, or made from your sample. Our engineering department is at your disposal.

- ▲Carbon Brushes
- ▲Graphite Brushes
- ▲Metal Graphite Brushes
- ▲Battery Electrodes
- ▲Contacts
- ▲Dash Pot Plungers
- ▲Discs
- ▲Electrodes
- ▲Packing Rings
- ▲Tubes
- ▲Welding Electrodes

WRITE FOR CATALOG

HELWIG CO.

3466 SO. THIRTEENTH STREET

MILWAUKEE, WISCONSIN

Mr. Chief Electrician!

—Don't take our word that NON-FLUID OIL will save money on motor up-keep costs—

Let us prove this.

When we tell steel mill men that NON-FLUID OIL will save them money not only on oil and application cost, but also by reducing the expense for maintenance—we are not making strong claims without proof.

During the last five years, when operating costs have been watched closer than ever, more steel mills have adopted NON-FLUID OIL than at any previous time.

These mills found that because it did not drip or leak, NON-FLUID OIL outlasted liquid oil 3 to 5 times, saving money on oil and application cost and preventing short circuits. By lubricating more dependably, NON-FLUID OIL also lessened bearing wear, reducing maintenance cost.

Check up by test right in your own plant. Write today for testing sample and full information.

●

New York & New Jersey Lubricant Co.

Main Office: 292 Madison Ave., New York, N. Y.

WAREHOUSES:

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NON-FLUID OIL

MODERN STEEL MILL LUBRICANT

Better Lubrication at Less Cost per Month

For Indoor or Outdoor Use

More **USEFUL** *Light*

In what way more useful?

—because it will be fresher, cleaner and brighter when it does not have to fight its way through accumulated dirt—

—a vast amount of light is lost by dirty reflectors.

THOMPSON SAFETY LOWERING HANGERS

—will help you to keep your lighting equipment clean and useful—easily and safely.

—no climbing nor electrical hazards.

—no dangling loops of wire.

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Send for descriptive matter and prices.

Handled by leading electrical supply houses.

THE THOMPSON ELECTRIC CO.

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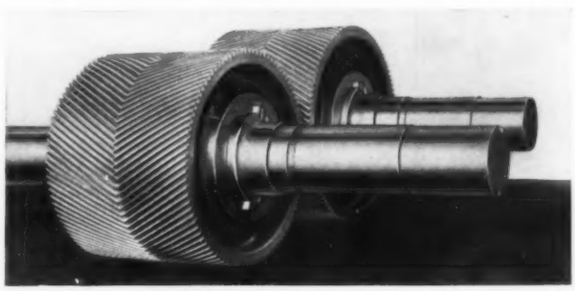
HIGH VELOCITY GEARING

Requires

EXTREME PRECISION *in* MANUFACTURE



These Farrel-Sykes continuous tooth herring-bone gears for the main reversing drive of a high speed blooming mill function perfectly at a peripheral speed of 4300 feet per minute.

Gears to operate at high speeds require a higher grade of engineering and manufacturing technique than is found in the average gear plant.

In the production of Farrel-Sykes Gears for high speed service special study is given to all the factors involved in order to produce gears that will operate with maximum efficiency, smoothness and quietness.

The development of the equipment and the technique for generating high precision gears is pursued intensively. The use of harder, stronger and better materials receives constant attention. Standards of accuracy are progressively improved.

These factors, combined with the inherent advantages of the Sykes Gear, result in extra load-carrying capacity, quiet operation and the ability to give long, trouble-free service under the severest conditions.

FARREL-BIRMINGHAM COMPANY, INC.

366 Vulcan Street, Buffalo, N. Y.

LARGEST BUILDERS OF THE WORLD'S LARGEST CRANES

Alliance Products

STANDARD CRANES
Up to 430 tons capacity

STRIPPING CRANES
Up to 320 tons capacity

COMBINATION CHARGERS and STRIPPERS
Up to 200 tons capacity

- Ladle Cranes
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275 of 100 Tons Capacity and Over

LADLE AND STANDARD CRANES

59		100 tons
2	WORM DRIVEN Ladle,	100 tons
2		115 tons
6	WORM DRIVEN Ladle,	125 tons
45		125 tons
30		150 tons
3	WORM DRIVEN Ladle,	150 tons
6	WORM DRIVEN Ladle,	160 tons
2	WORM DRIVEN Ladle,	165 tons
7	WORM DRIVEN Ladle,	175 tons
27		175 tons
3	WORM DRIVEN Ladle,	200 tons
4		200 tons
5		225 tons
1		250 tons
3	WORM DRIVEN Ladle,	250 tons
3	WORM DRIVEN Ladle,	275 tons
1		275 tons
1		300 tons
3		430 tons

STRIPPING CRANES

8		100 tons
1		125 tons
22		150 tons
19		200 tons
1	Single Ram,	320 tons

COMBINATION CHARGERS AND STRIPPERS

3		100 tons
1		125 tons
3		150 tons
4		200 tons

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THE ALLIANCE MACHINE CO.

ALLIANCE, OHIO, U.S.A.

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WISHES YOU—ONE AND ALL

Merry Christmas

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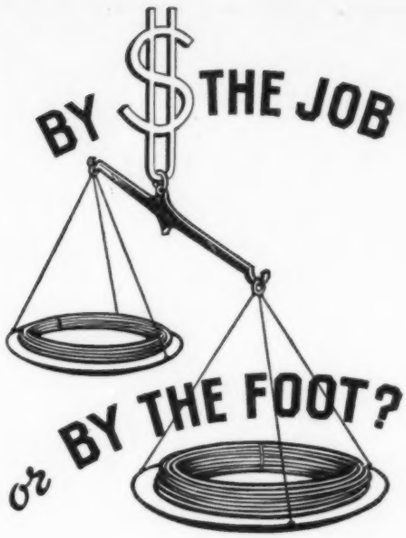


Here's a paradox. *By the foot* Rockbestos wire and cable may cost more than non-asbestos protected constructions—*by the job* it often costs *less!* The answer is that a Rockbestos wire circuit, either open or in conduit, can be the *shortest distance* between two points, regardless of boilers, kilns, steam pipes and other enemies of ordinary insulation. Thus, the heat resistance and long life characteristic of Rockbestos insulated wires and cables can often be yours without extra material cost, not to mention time saved in installation.

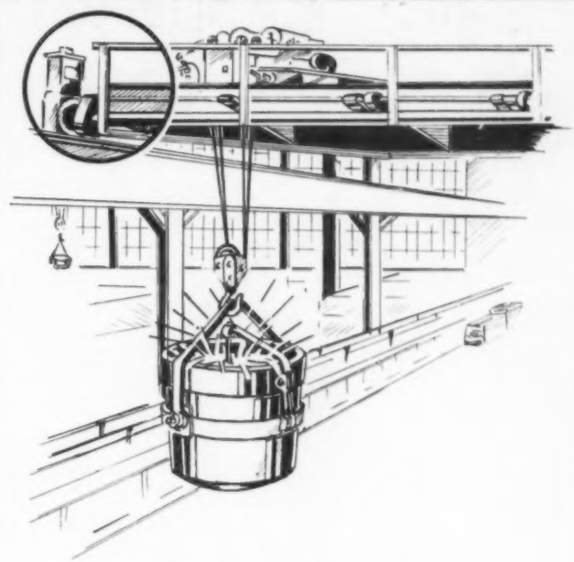
We will gladly explain the insulation construction of our wires, cables and cords, detailing the qualities that make Rockbestos the wire for severe service requirements — and, if possible, will recommend from our more than fifty standard types the one adapted to your particular need. Specifications and quotations also given on special constructions.

Rockbestos A.V.C. wire and cable is available in any required size up to 2,000,000 C.M. and for service voltages up to 7500. Our catalog shows many types and suggests applications. Send your request for one to Rockbestos Products Corporation, New Haven, Conn.

A.V.C.
Boiler Room Wire

ROCKBESTOS

the wire with permanent insulation



Save Crane Time and Eliminate Accidents

TYING up expensive cranes while the operator crawls out to sand the rails is old-fashioned, wastes time both of cranes and men, and can be a fruitful source of accidents in any busy plant.

LINTERN ELECTRO-MAGNETIC SANDERS do the job vastly more efficiently than by hand. Both rails are sanded evenly, saving wheel wear and crane misalignment. There's no interference with crane operation because the rails are sanded while the crane is in use, merely by pressing a button in the cab. Since the operator need not leave his cab, an important source of accidents is eliminated.

Lintern Crane Sanders have been used for more than 10 years by important steel and automotive plants, and are specified on many Government projects. Modernize your own cranes, eliminate dangerous accident possibilities, and cut your own costs of crane operation. The cost is very small. Write for Catalog E-3.

THE NICHOLS-LINTERN CO.

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Manufacturers also of the
N-L Mechanical Sander for Locomotive Cranes

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CIRCULAR COILS
ON YOUR DISTRIBUTION TRANSFORMERS!

1

Every turn of wire at uniform tension throughout its length —stronger!

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2

No short circuit stresses to distort coil-reliability!

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Absence of corners eliminates possibility of cracking insulation —longer life!

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Performance records on "SA" Series Brushes establish the superior commutating properties of these new grades for heavy duty D. C. service.

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The broad field of service to which "SA" Series brushes are suited, and the graduated physical properties of the individual grades, permit the selection of a brush with the right combination of characteristics to provide both good commutation and good life.

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Let us recommend the grade for your service

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Manipulators
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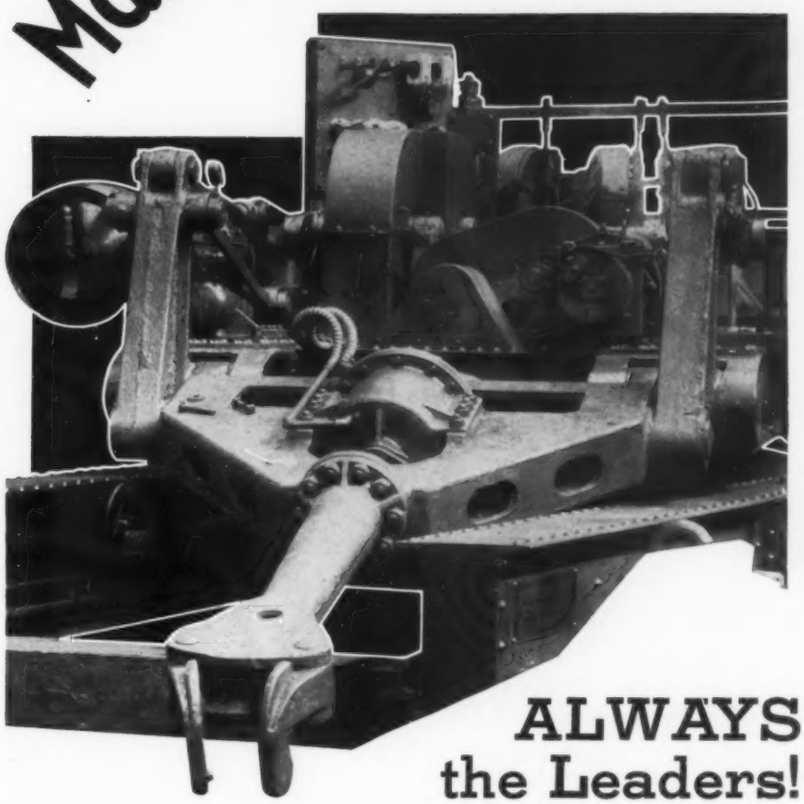

ALWAYS the Leaders!

Wellman originated the mechanically operated charging machine -- and every step in our development of this giant steel hand has been a big stride forward in handling speed and economy. Wellman chargers and manipulators are the nearest thing to completely automatic machines.

WELLMAN PRODUCTS INCLUDE:

Steel Mill Equipment . . . Charging Machines, Cars and Boxes . . . Manipulators . . . Coal and Ore Handling Bridges . . . Gantry Cranes . . . Special Cranes . . . Clamshell Buckets . . . Car Dumpers, all types . . . Blast Furnace Skip Hoists . . . Gas Producers, Flues . . . Gas Reversing Valves . . . Mining Machinery . . . Safety Stops for Traveling Structures . . . Welded Steel Construction . . . Castings and Machine Work to customers drawings.

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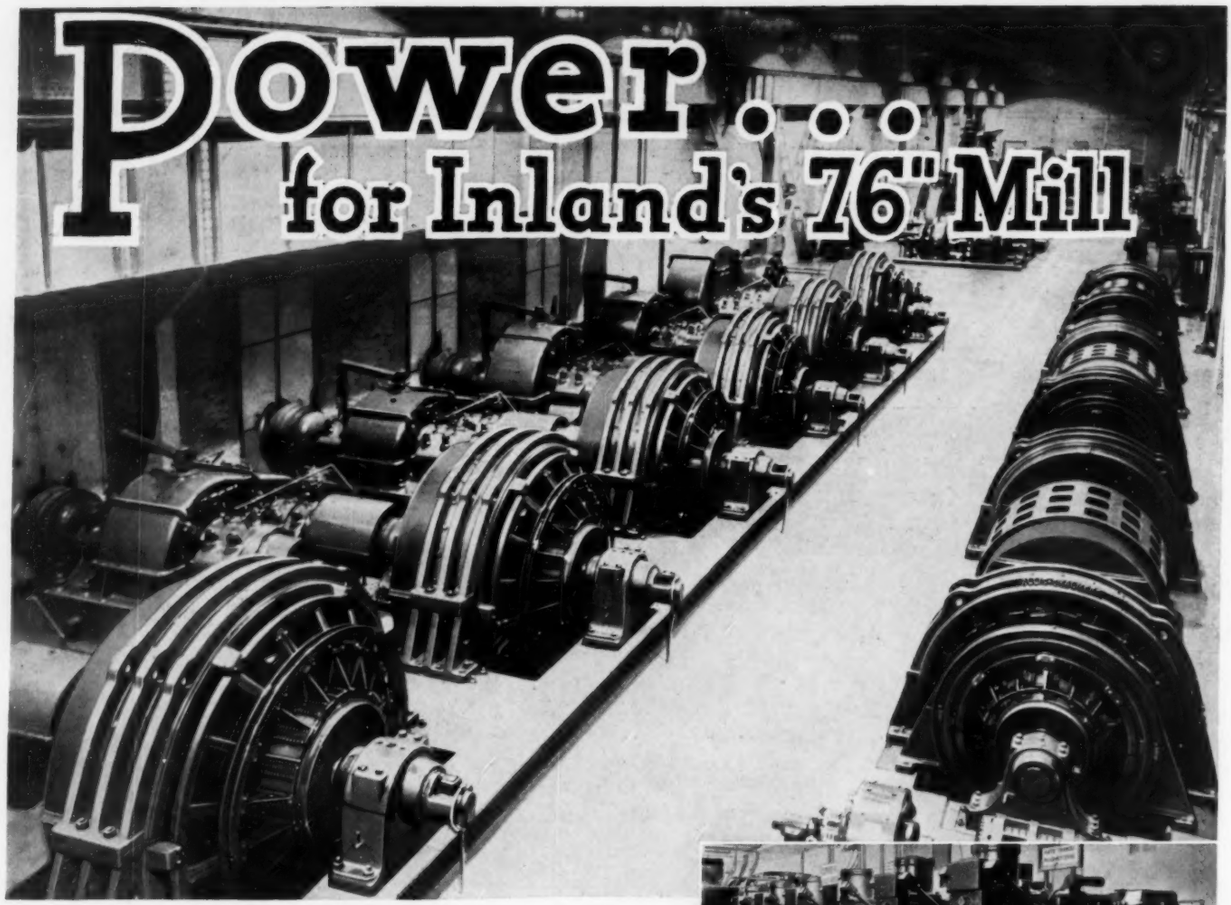
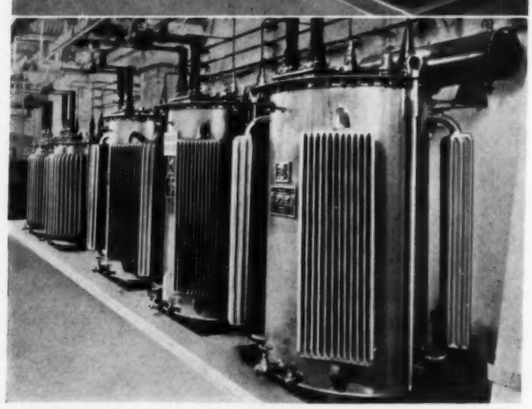
Power . . . for Inland's 76" Mill





Dependable Power Equipment

WHEN rolling strip, sheet or plate to accurate gauge it is necessary to shut down at regular intervals to change the working rolls, but, continuous service should be demanded of the power equipment.

The six 3500-hp, 600-volt, 175/350-rpm finishing stand motors, 500-hp scale breaker motor and the six supporting 2500-kw, 600-volt synchronous motor driven generators shown above have "Frog-leg" type armature windings providing 100% cross connection. In operation over two years carrying peak loads ranging up to 12,000-amperes (approximately 2-1/2 times normal rated motor current) on the last stands, no interruptions have occurred due to commutation troubles or flash-overs.

The transformers shown at the right furnish continuous service for mill auxiliaries and lighting.

Starting and running oil circuit breakers are of the compact, safety type, Allis-Chalmers Reyrolle metal-clad construction. The running breakers illustrated are rated 700-ampere, 15,000-volts, with circuit interrupting capacity of 250,000-kva.

Allis-Chalmers engineers have solved many electrical problems introduced by recent developments in operation of rolling mills of all types. You are invited to submit your problem to them for the proper solution.

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee

POTENTIOMETERS THAT HAVE RELIABLE STANDARDS

The electrical balance called a potentiometer can be no better than the standard against which it balances the electromotive force from the thermocouple.

That is why the modern Micromax wide-scale potentiometer maintains its working standard automatically . . . checking it at frequent, regular intervals against the standard cell.

Just as the original Leeds & Northrup potentiometer eliminated the variables and uncertainties of the millivoltmeter, so the modern, wide-scale Micromax eliminates uncertainties as to the constancy of the working standard.

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THE MICROMAX FAMILY—INDICATORS, RECORDERS AND CONTROLLERS

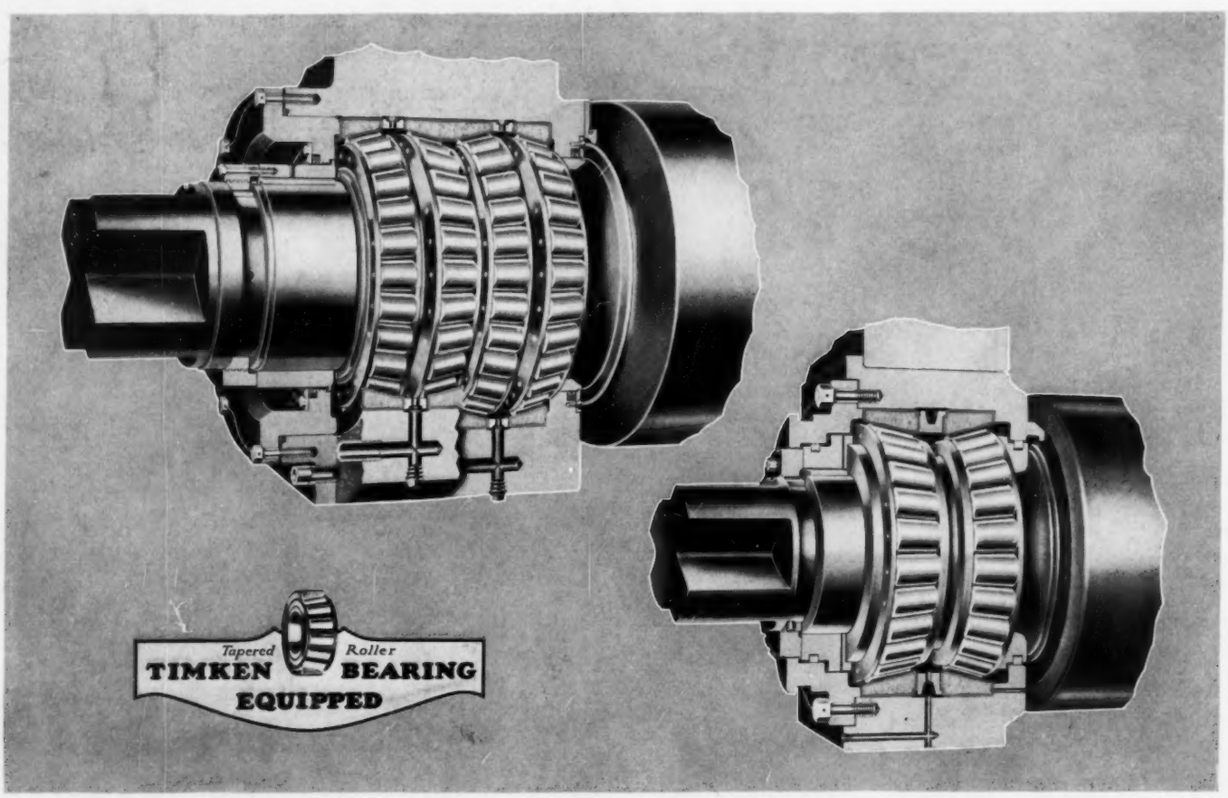
I-400

EXPERIENCE

Is the Basis of Timken Roll Neck Bearing Success

It is the experience they represent that makes Timken Roll Neck Bearings your best investment. When you buy Timken Bearings for your roll necks you will not receive merely so many tons of steel and an invoice. You will get a perfected product representing 12 years of continuous development, plus specialized engineering service embodying the knowledge gained in applying Timken Bearings to all types of hot and cold mills in the plants of 74 leading American mill operators. Furthermore, your satisfaction and the safety of your investment are guaranteed by a financially strong and fully responsible institution —an institution that has never left a customer "holding the bag", and never will. You will find that it pays to specify Timken Roll Neck Bearings.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO



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